Outline

NDRI

I. Introduction

II. Methodology

III. Pilot test

IV. Conclusions

V. Next steps

Sections of the Methodology

NDRI

1. Forming the technical architecture concept
2. Dividing electronics into domains
3. Setting the role of a domain's technical architecture
4. Structuring a domain's technical architecture
5. Reducing military specifications
6. Reusing hardware and software
7. Interoperating weapon and C4I systems
8. Coordinating TAs across services/agencies
9. Integrating TAs across domains

Strategic Goals for Interoperabilty of Weapon System Electronics

NDRI

To sustain superior warfighting effectiveness, DoD is pursuing three strategic goals for weapon system electronics

- **Quick insertion of new technology**
- **Lower life-cycle costs for weapon system electronics**
  - **Hardware**
  - **Software**
- **More effective joint operations**
  - **Among weapon systems**
  - **Between weapon and C4I systems**

Three Tactics Are Key To Achieving DoD's Goals

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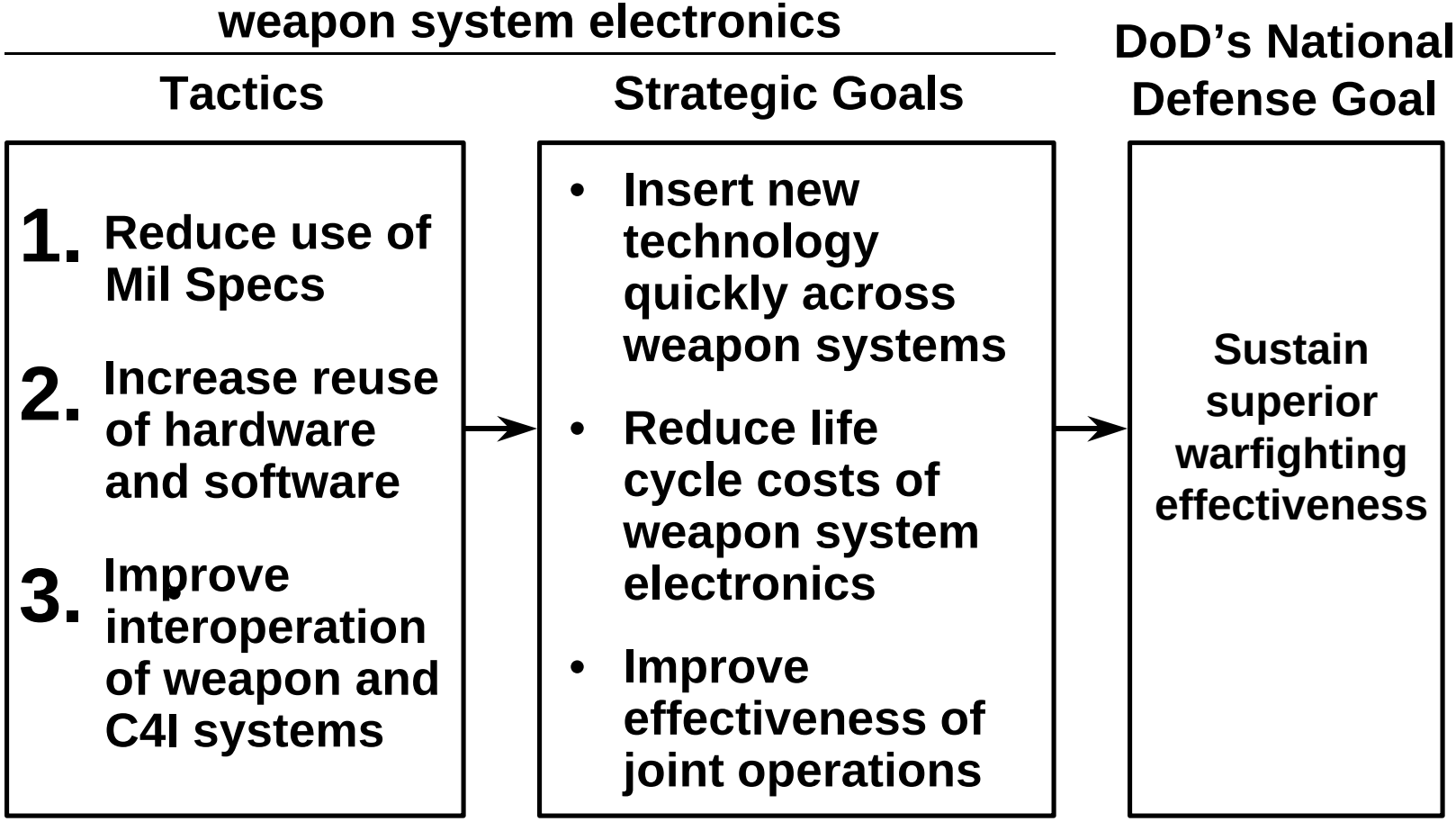
DoD's efforts to improve interoperability of weapon system electronics



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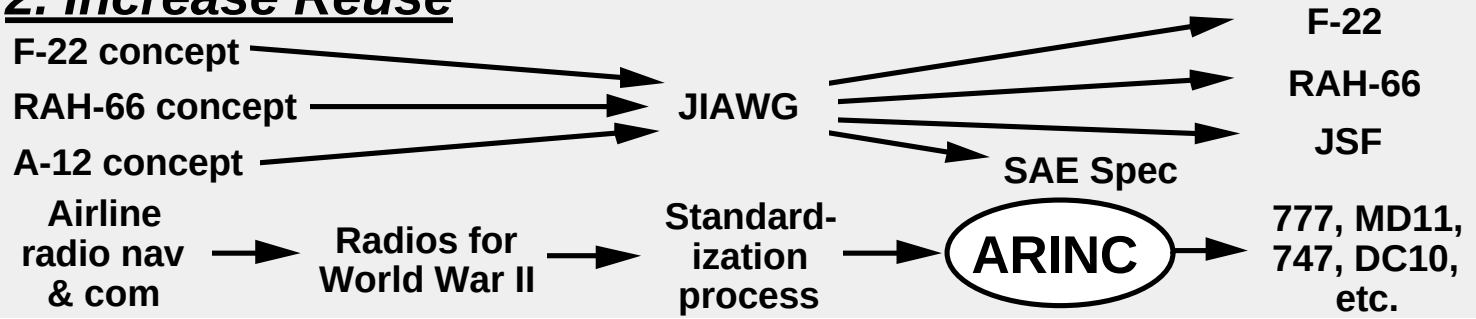
JACG, ARINC, and JTA Can Be Pathfinders for DoD's Three Tactics

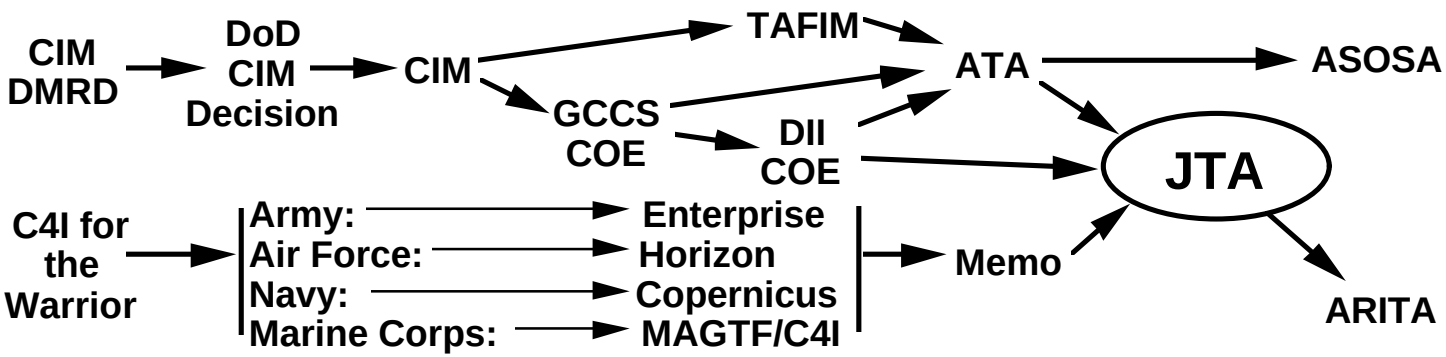
NDRI

1. Reduce Mil Specs

2. Increase Reuse



3. Improve Interoperation



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Extent of Experiences in Developing and Using the Three Tactics

NDRI

Tactics for improve-ment	Phases in developing and using new architectures and new practices					
	New architectures or practices			Apply to new systems		
	Identified	Developed	Implemented	Development	Test	Operations
1. Reduce Mil Specs	JACG Guide Specs GOA	JACG NGS				
2. Reuse HW/SW		ASOSA	JIAWG	F-22 IFTE	Comanche MATE	ARINC
3. Weapon system C4I interfaces		ARITA	ATA JTA TAFIM			

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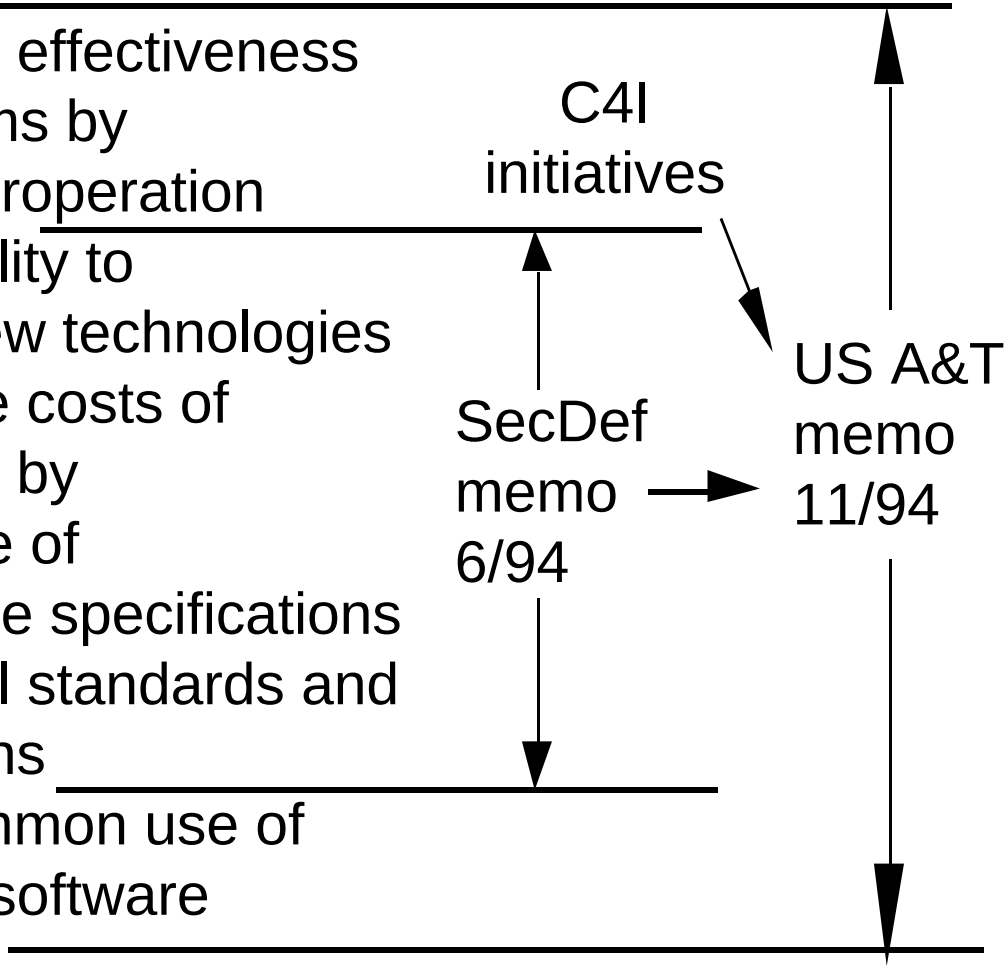
DoD Policy Memos That Stimulated Development of the Three Tactics

NDRI

- Maintain superior effectiveness of weapon systems by
  - Improving interoperation
  - Increasing ability to incorporate new technologies
- Reduce life cycle costs of weapon systems by
  - Increasing use of
    - Performance specifications
    - Commercial standards and specifications
- Increasing common use of hardware and software



USD A&T Memo (11/94) Calls for Open Systems To Improve Interoperability

NDRI

- "...directing that open systems specifications and standards (electrical, mechanical, thermal, etc.) be used for acquisition of weapon systems electronics to the greatest extent practical."
- "Open system specifications and standards are concensus-based public or non-proprietary specifications and standards for systems and interfaces of hardware, software, tools, and architecture."
- "...these systems and subsystems shall be designed, developed, and constructed as open systems during the acquisition and modification process to reduce life-cycle cost, and to facilitate effective weapon system intra- and interoperability."
- "I hereby establish the open Systems Joint Task Force to sponsor and accelerate the adoption of open systems in electronices included in weapon systems acquisitions."

Research Hypothesis

NDRI

Our research hypothesis has two parts

- **The technical architecture approach developed by the C4I community can be extended to weapon system electronics**

- **We can formulate a practical method for guiding the development of technical architectures for weapon system electronics**

Approach to Designing Methods for Developing Technical Architectures

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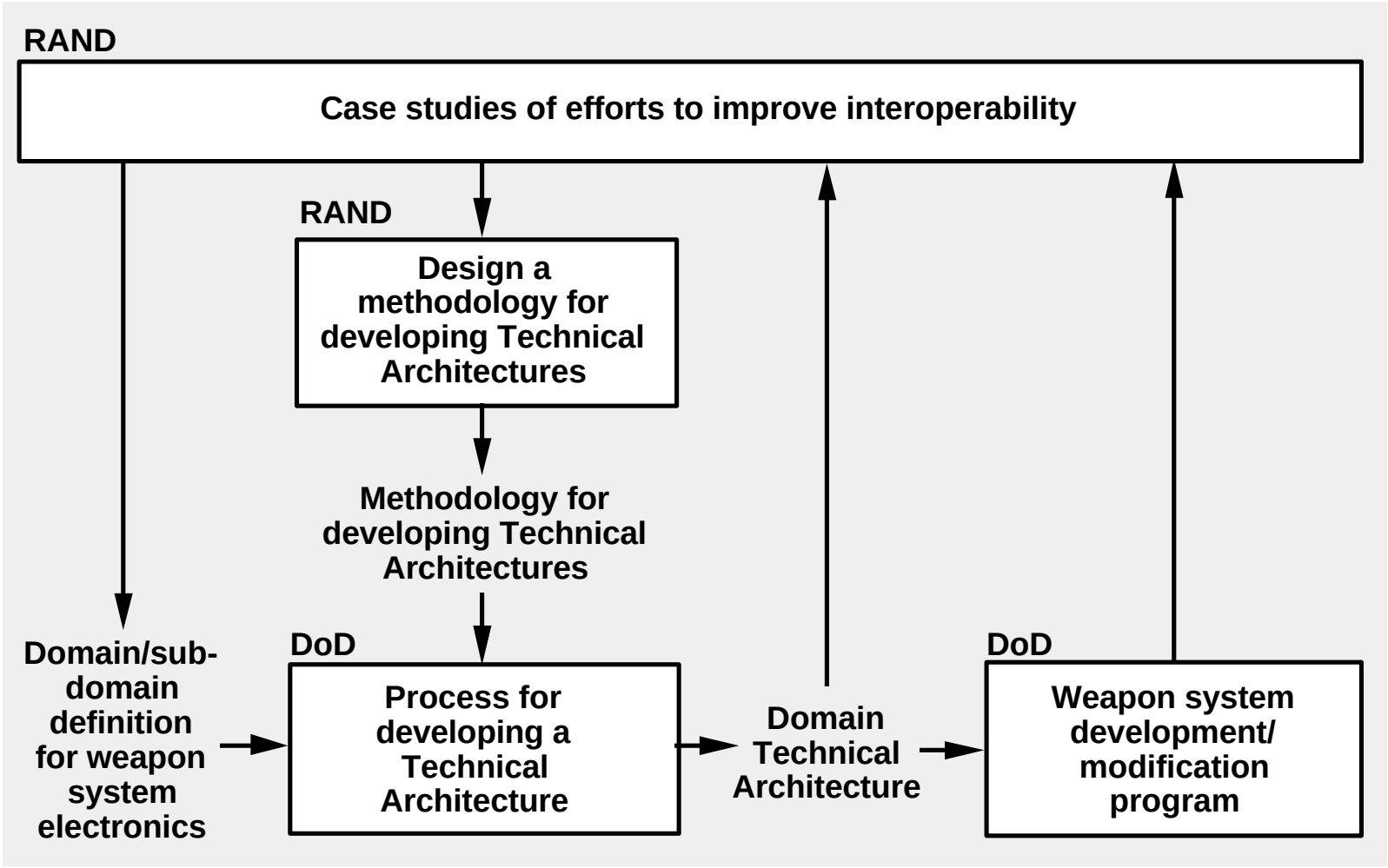

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Strategy for Improving Interoperability Aims To Evolve a Methodology

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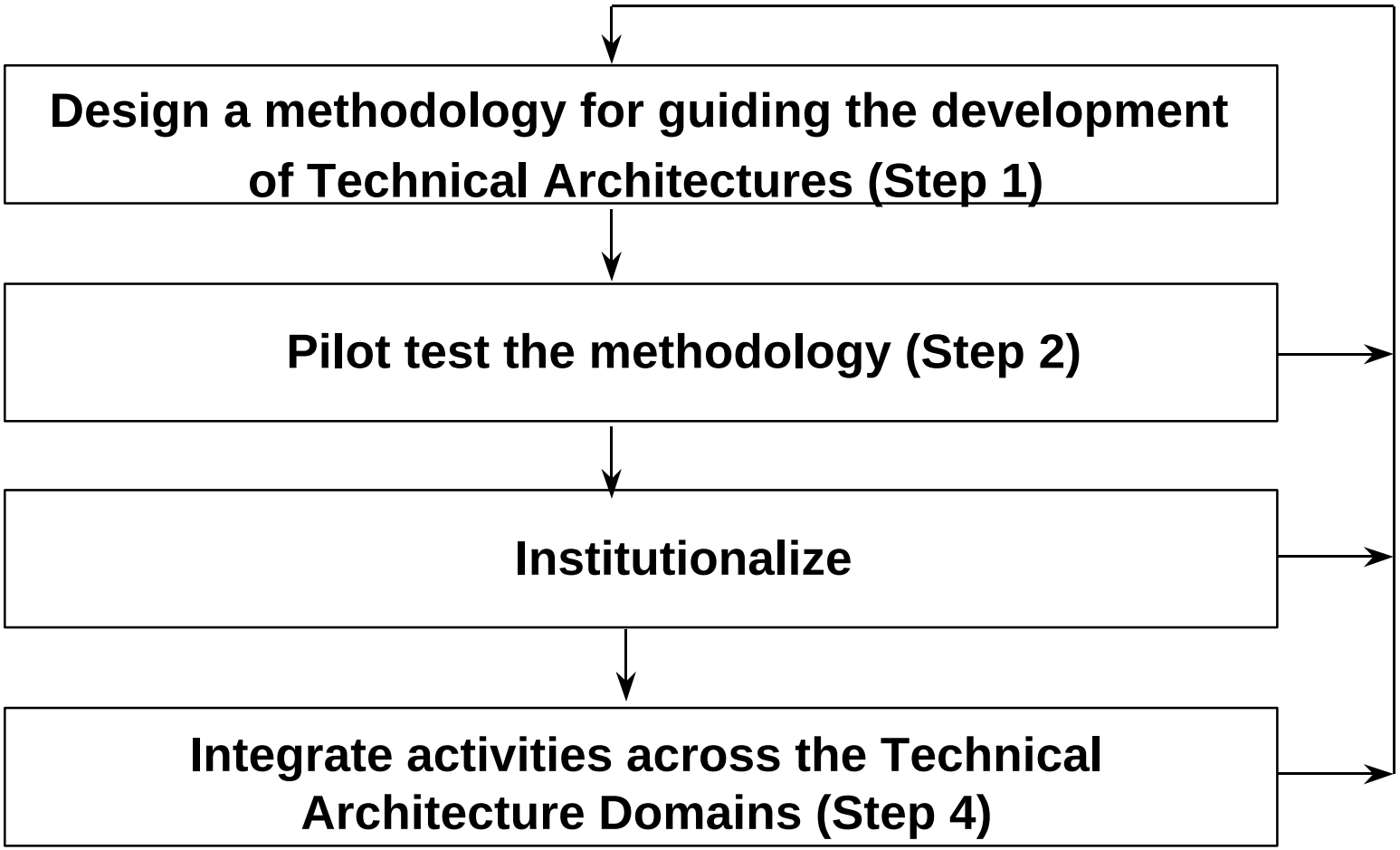


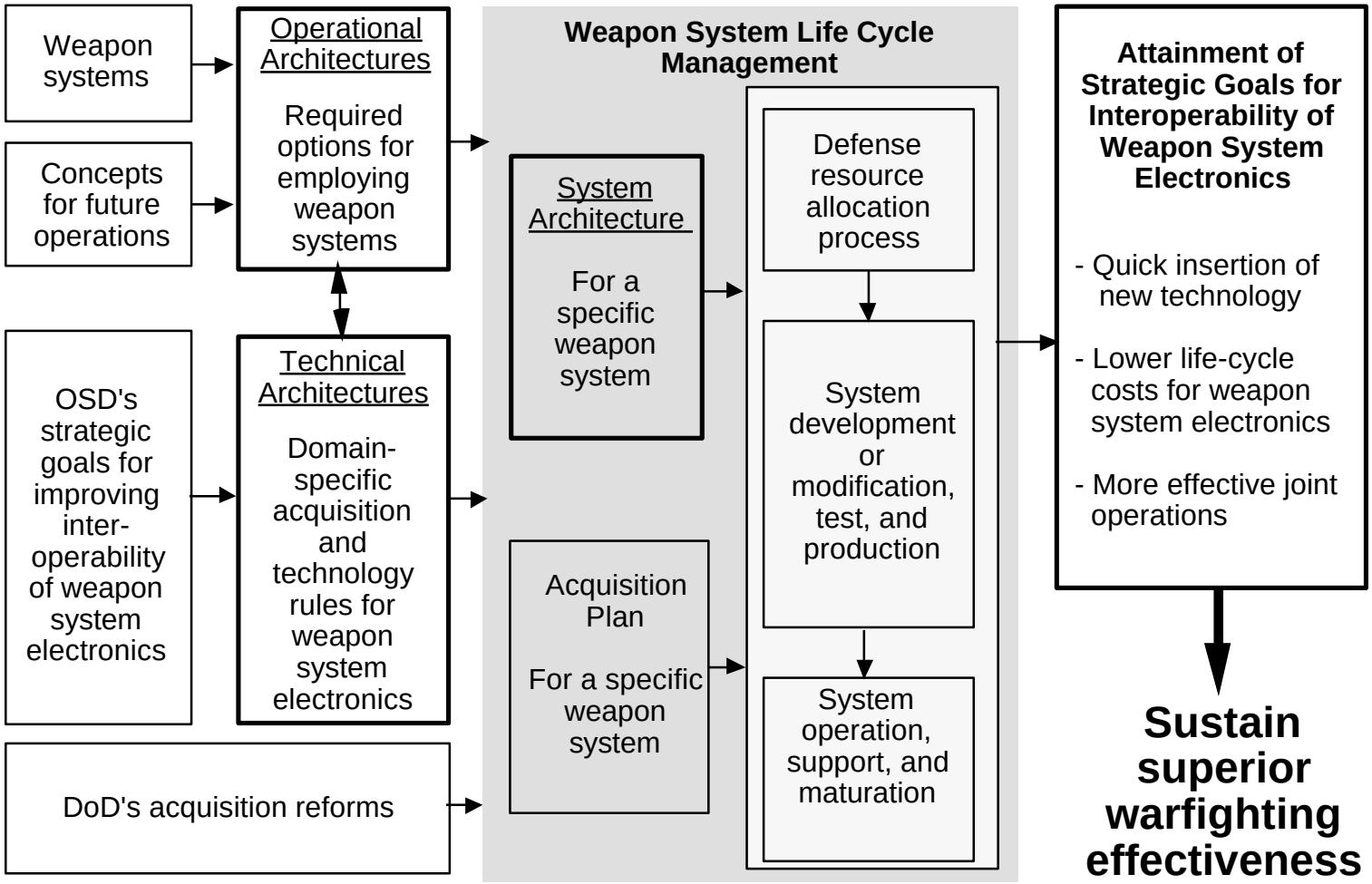
The Hypothesized Role of a Technical Architecture for WS Electronics

NDRI

- Divide DoD's weapon systems electronics into domains and subdomains
- For each weapon system electronics domain/subdomain
  - Require the services and the defense agencies to develop a set of rules for improving interoperability
  - Define the rules for a domain as the domain's/subdomain's technical architecture
  - Use the technical architectures to develop and review acquisition / modification programs at the PEO, Acq Exec, and OSD levels

A Concept for Adapting the C4I Technical Architecture Approach

NDRI



Extend the Operational Architecture Concept to Weapon Systems Electronics

NDRI

Comparison of operational architecture concepts

- **C4I context**
  - **Focuses on C4I information exchanges**
  - **Deals with information management systems**
- **Weapon systems electronics context**
  - **Focuses on many types of interactions**
    - » **Information**
    - » **Jamming**
    - » **Support**
  - **Deals with weapon system electronics**
    - » **Depicts operational context for each weapon system's electronics across a domain**

Extend the Systems Architecture Concept to Weapon Systems Electronics

NDRI

Comparison of systems architecture concepts

- **C4I context**
  - Focuses on C4I information management systems
  - Defines the C4I systems and their information interchange requirements
- **Individual weapon system, electronics context**
  - Focuses on HW and SW for a weapon system
  - Defines the system elements and their arrangement
- **Weapon systems electronics domain context**
  - Focuses on generic style of HW and SW for a domain
  - Defines the system elements and their arrangement

Extend the Technical Architecture Concept to Weapon Systems Electronics

NDRI

Comparison of technical architecture concepts

- **C4I context**
  - **Focuses on technical services, interfaces, and standards**
  - **Considers all C4I**
- **Weapon systems electronics context**
  - **Focuses on identifying a sufficient set of rules to assure opportunities to achieve strategic goals**
    - » **Technical**
    - » **Institutional and other as needed**
  - **Considers one domain of weapon systems electronics at a time**

Sections of the Methodology

NDRI

1. Forming the technical architecture concept
2. Dividing electronics into domains
3. Setting the role of a domain's technical architecture
4. Structuring a domain's technical architecture
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DoD Has Defined Domains for Weapon System Electronics

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- Aviation
- Space vehicles
- Maritime vessels
- Automated test equipment
- Ground vehicles
- Missile defense systems
- Missiles
- Munitions
- Soldier systems
- Surveillance / reconnaissance

Types of Considerations That Should Influence the Definition of Domains

NDRI

- **Technical-economic**
  - **Technical distinctions that divide electronics into similiar classes**
  - **Economics of developing and supporting technical architectures**
    - » **Evolution with changing needs and technology**
    - » **Maturation to achieve continuous improvement**
- **Instituitional**
  - **Cross service coordination and approval**
  - **Incentives versus enforcement**
- **Integration**
  - **Heirarchical arrays of domains**
  - **Flat network of domains**

The Issue of Subdomains, A Technical-Economic Consideration

NDRI

- Example of designing hardware for too broad of a domain
  - Development costs spread over large production run
  - But, production costs rise due to too broad a range of
    - » Environments
    - » Packaging requirements
  - Each produced unit needs capabilities for extremely different environmental conditions / packaging
- Example of widely different environmental needs
  - Fighter aircraft and helicopters
    - » High altitude and high g loading for fighters
    - » Low altitude and low g loading for helicopters
  - Vibration:
    - » High frequency, low amplitude for fighters
    - » Low frequency, large amplitude for helicopters

Economic Considerations that May Segment Domains into Subdomains

NDRI

- **Environment factors**
  - **Dynamic loads**
    - **Vibrations**
    - **Maximum g load**
  - **Altitude**
  - **Cleanliness**
  - **Corrosion**
  - **Moisture**
- **Packaging factors**
  - **Weight criticality**
  - **Volume criticality**

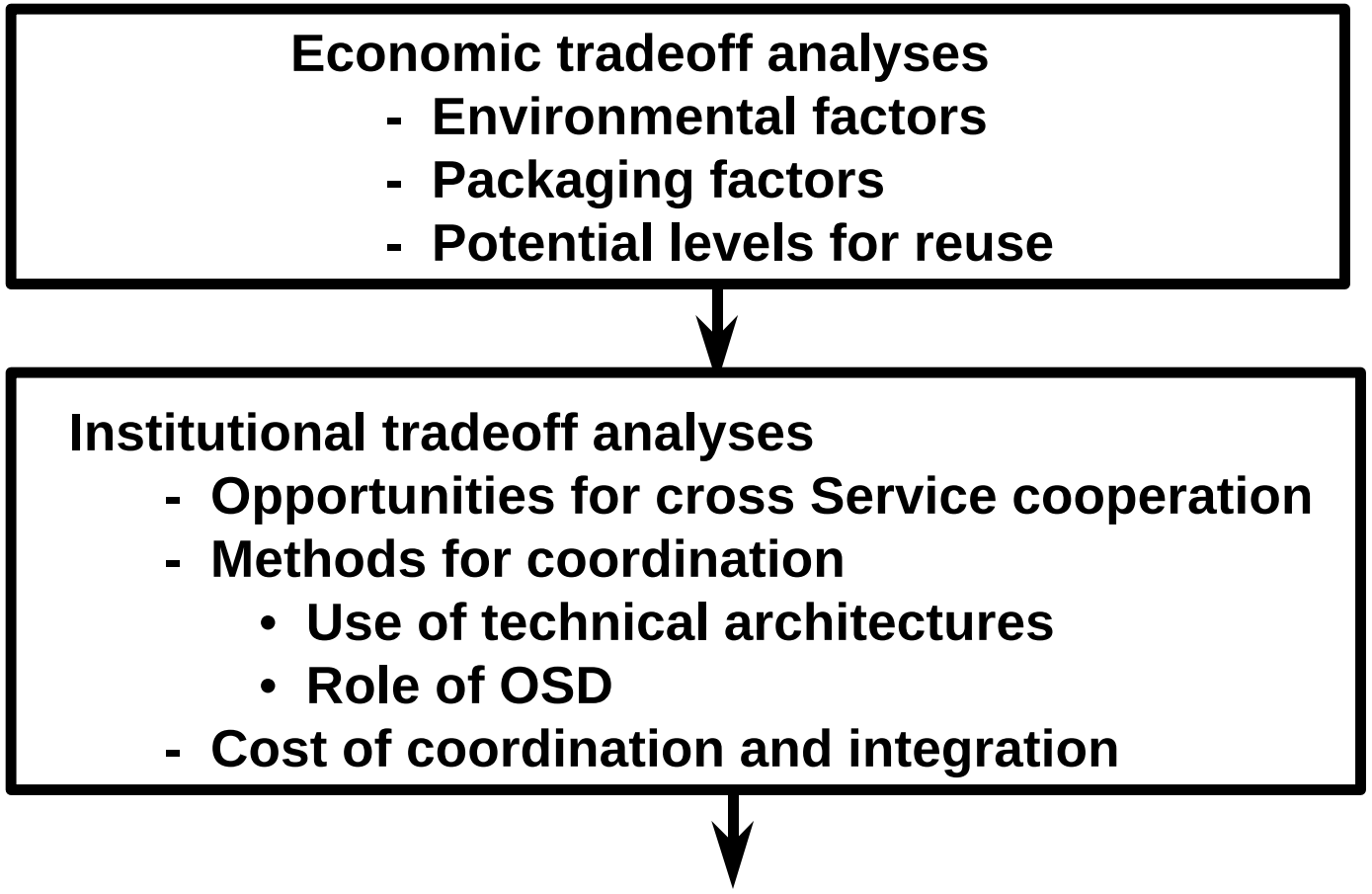
Method for Subdividing Weapon System Electronics into Domains (1 of 2)

NDRI

- Environmental assessment
  - Assess range of environmental conditions
  - Analyze influence on design and costs for development, maturation, production, and support
- Packaging assessment (hardware and software)
  - Assess range of packaging needs
  - Analyze influence on design and costs for development, maturation, production, and support
- Levels assessment
  - Assess economics of reusing hardware and software at levels of potential interest
  - Consider reuse at component level, subassembly level, etc.
- Analyze economics of domain breadth considering environmental, packaging, and levels targeted for reuse

Method for Subdividing Weapon System Electronics into Domains (2 of 2)

NDRI



An Example Domain Division Based on Environment, Packaging and Level Factors

NDRI

Aviation

- Fighter and attack aircraft
- Strategic bombers
- Transport and tanker aircraft
- Large electronic platform aircraft
- Attack/scout helicopters
- Transport helicopters
- Uumanned aerial vehicles

Ground vehicles

- Tanks
- Other armored vehicles
- Off-road heavy transport
- Off-road light transport
- On-road heavy transport
- On-road light transport

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NDRI

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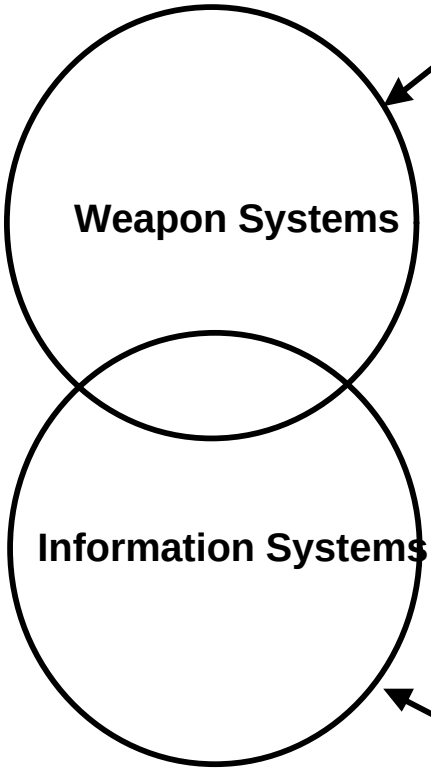
Examples of Technical Architectures

NDRI

- C4I Joint Technical Architecture (JTA)
- Army Technical Architecture for information systems (ATA)
- Airborne Reconnaisance and Intelligence Technical Architecture (ARITA)
- Joint Integrated Avionics Working Group (JIAWG)
- Modular Automated Test Equipment (MATE)
- ARINC specifications for transport aircraft avionics

Distinction Between Weapon Systems and Information Systems

NDRI

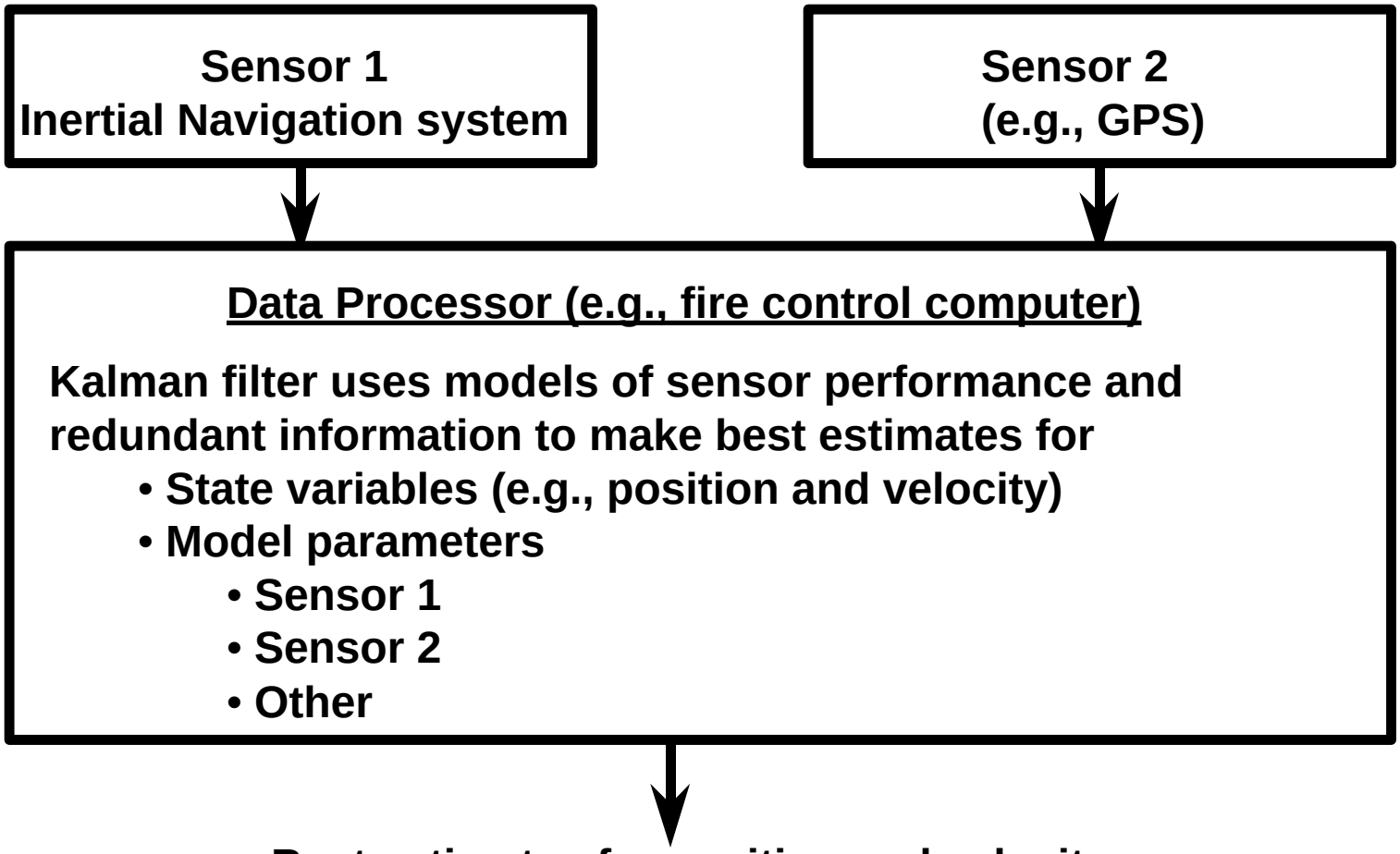


Real time functional control systems
- Response times are critical to mission success and surviv
- Weapon system response time is influenced by
  - Response times of many parts of the system
  - Ability to maintain optimal conrtrol of functions in real time
    - Requires models to represent response from alternative control inputs
    - Must model the performance of hardware and software in the operating environment in real ti
    - Must represent hardware's dynamic reaction to changing environment
- Modeling of system and function performance
  - Ties software to specific hardware
  - Makes reuse dependent upon hardware and software

Provide information, but do not control functions in real time
- Software can be developed independent of the hardware
- Reuse depends upon interface specifications

The Kalman Filter Example Illustrates Modeling Complexity

NDRI



Distinctions Between Information Systems and Weapon Systems

NDRI

Design factor	Information System Development Process	Weapon System Development Process
Objective	Inform	Real-time control of the weapon system to beat the threat and survive
Essential considerations	Accuracy, completeness, and timeliness	Minimize weapon system response time Real-time modeling of weapon system performance in the operating environment
Approach	Populate databases and provide user friendly access	Distributed modeling of system elements
Implications for a domain's Technical Architecture	Supports a high degree of modularity Allows focus on software	Modularity, although desireable and sought, is difficult to achieve Drives architecture, software, and hardware

Technical Architecture's Elements Depend on Type of System

NDRI

Comparison of an Information Systems Technical Architecture with the Necessary Elements of a Weapon System Technical Architecture

Elements of the technical section of a Technical Architecture	Mechanization rules		Implementation rules	
	Information management systems	Weapon systems	Information managment systems	Weapon systems
Architectural configuration ("style") for the domain	x	xxxx		xx
Software	xxx	xxx		xx
Hardware		xxx		xx

Mechanization rules include specification of a system architecture and specification of interface requirements.

Implementation rules include institutional rules and resource rules that govern joint development of harware and software.

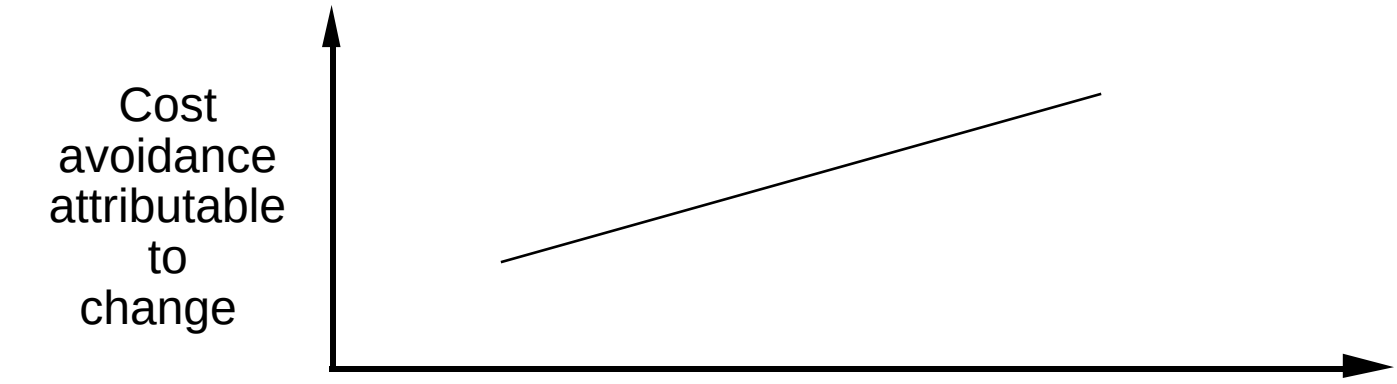
Challenges To Extending Technical Architectures To Weapon Systems

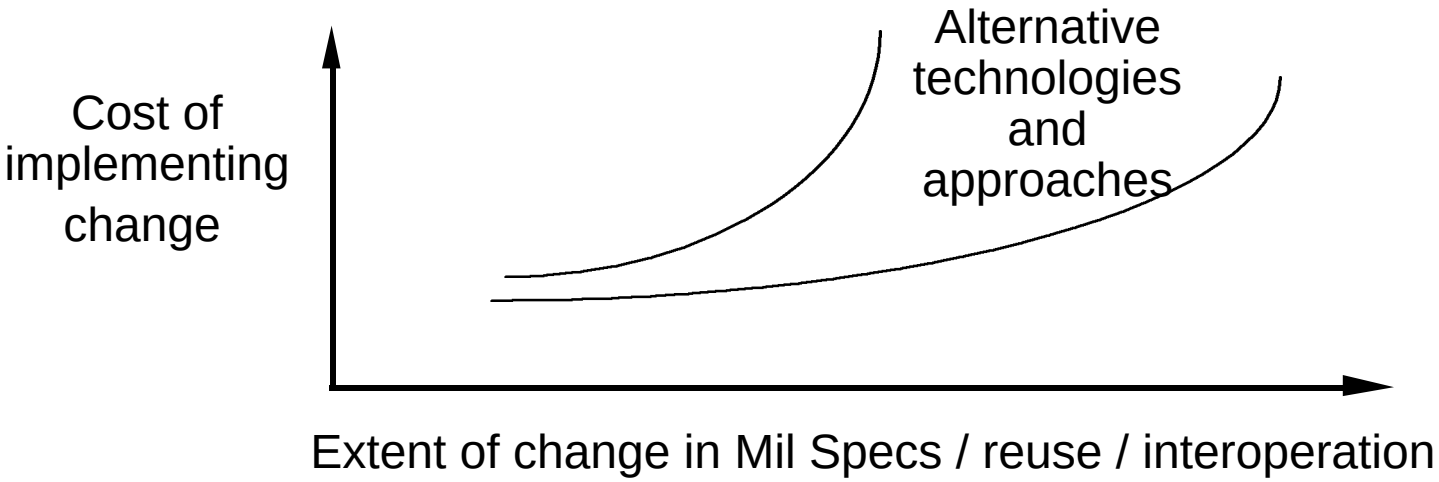
NDRI

- Differences that may influence the approach to developing technical architectures that aim to achieve OSD's interoperability goal
  - Differences between information systems and weapon systems
  - Differences among weapon systems
- Need for front-end investment
- Problems coming up in the world
  - Growing emphasis on using commercial products in military systems
  - Speed up in the obsolesence of technology

Tradeoffs Need To Be Managed Across Systems

NDRI





Potential Types of Rules for a Technical Architecture for a Weapon System

NDRI

- Technical
- Institutional
- Development, validation, and evolution
- Maintenance and maturation
- Resources
- Schedule

Sections of the Methodology

NDRI

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Rules and Tactics for a Weapon System Electronics Technical Architecture

NDRI

Types of Rules Comprising the Technical Architecture	Tactics for Improvement: Reduce Mil Specs	Reuse H/W and S/W	Improve interoperation
Technical			
Institutional			
Development, validation, and evolution			
Maintenance and maturation			
Resources			
Schedule			

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Content of Technical Architecture Needs To Focus on a Domain's Opportunities

NDRI

Types of Rules Comprising the Technical Architecture	Tactics for Improvement		
	Reduce Mil Specs	Reuse H/W and S/W	Improve interoperation
Technical		XXXX	XX
Institutional		XXXX	
Development, validation, and evolution			
Maintenance and maturation			
Resources		XXXX	
Schedule			

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Development and Integration of Domain Technical Architectures

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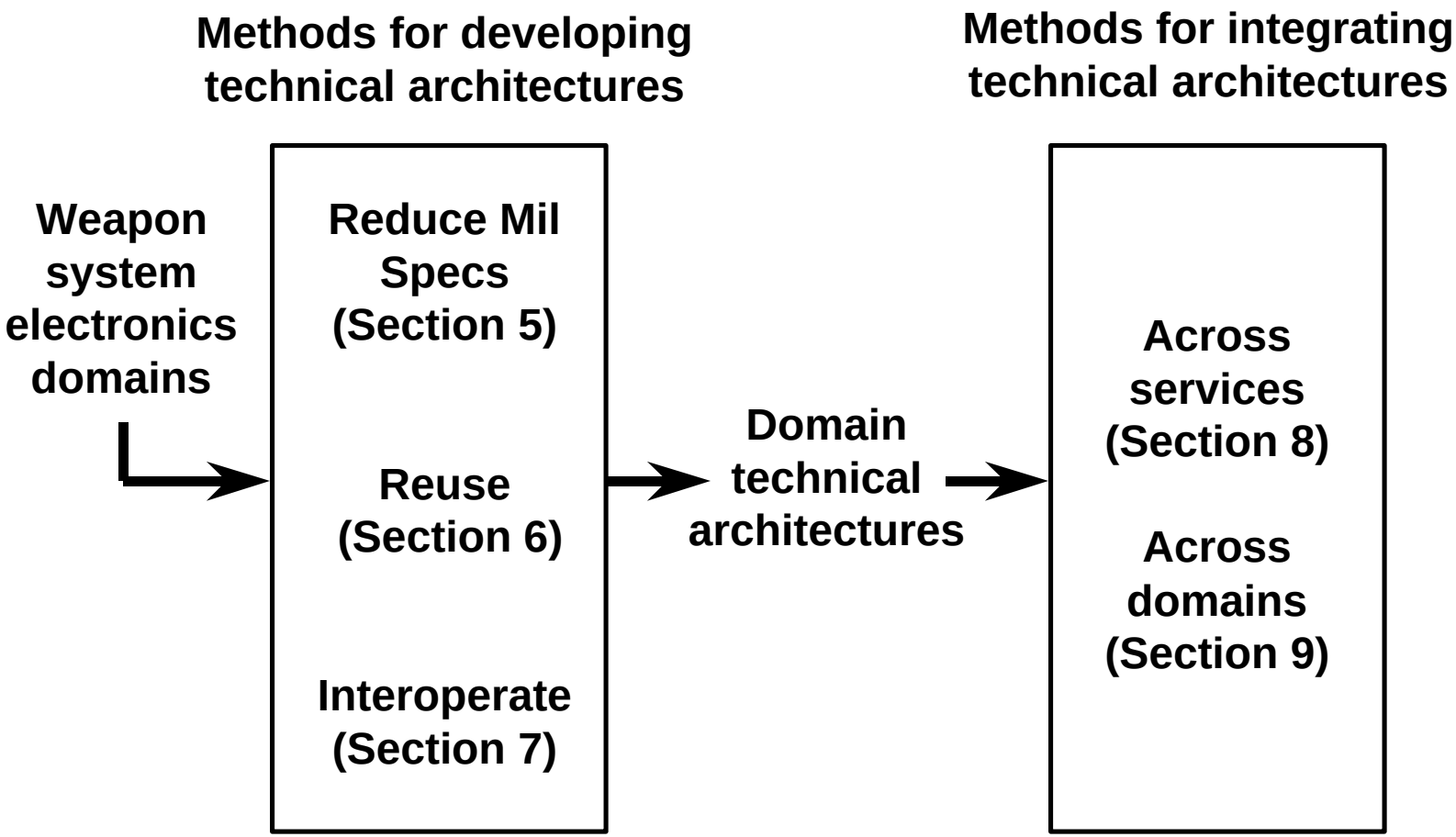

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An Illustrative Structure for Organizing a Technical Architecture

NDRI

TA Section 1. Technical

TA Section 2. Institutional

TA Section 3. Development, validation, and evolution

TA Section 4. Maintenance and maturation

TA Section 5. Resources

TA Section 6. Schedule

Technical Section of a Technical Architecture for WS Electronics (1 of 4)

NDRI

1.1 **Operational architectures**

1.1.1 • **Domain Operational Architecture**
  – **Functions to be provided by the domain's electronics, and their interdependencies**

1.1.2 • **Domain Software Operational Architecture**
  – **Functions to be provided by the domain's software, and their interdependencies**

1.1.3 • **Domain Hardware Operational Architecture**
  – **Functions to be provided by the domain's hardware, and their interdependencies**

Technical Section of a Technical Architecture for WS Electronics (2 of 4)

NDRI

1.2 **System architectures**

1.2.1 • **Domain system architecture(s)**

– **Equipment architectural style(s) for the domain: the general principles for arranging the electronics hardware and software for the domain**

1.2.2 • **Domain software system architecture(s)**

– **Software architectural style(s) for the domain: the general principles for arranging the software**

1.2.3 • **Domain hardware system architecture(s)**

– **Hardware architectural style(s) for the domain: the general principles for arranging the hardware**

Technical Section of a Technical Architecture for WS Electronics (3 of 4)

NDRI

1.3 **Interface requirements**

1.3.1 • **Domain interface requirements**

– **Principles, practices, and standards to be adhered to in the design of system harware and software elements compliant with the architectural style**

1.3.2 • **Domain software interface requirements**

– **Principles, practices, and standards to be adhered to in the design of system software compliant with the architectural style**

1.3.3 • **Domain hardware interface requirements**

– **Principles, practices, and standards to be adhered to in the design of system hardware compliant with the architectural style**

Technical Section of a Technical Architecture for WS Electronics (4 of 4)

NDRI

1.4 • **Technical reference models defining the entities addressed by the technical architecture**

1.5 • **Additional standards that will be adhered to within the domain**

Institutional Section of a Technical Architecture (1 of 2)

NDRI

2.1 • **Functions of institutions that are required to**
  - **Develop, validate, evolve, maintain, and mature the technical architecture**
    - » **Requirements for organizations and weapon system programs to perform life-cycle management tradeoffs**
      - **For a weapon system**
      - **Across weapon systems**
      - **Across services**
  - **Apply, incentivize and enforce the technical architecture**

2.2 • **Division of responsibility and authority across institutions for providing the required functions**

Institutional Section of a Technical Architecture (2 of 2)

NDRI

2.3 • **Interface requirements for participating institutions**
  - **Guidelines for intra-domain coordination across organizations and programs**
  - **Guidelines for inter-domain coordination**
    - » **Technical architectures**
    - » **Organizations and programs**
  - **Guidelines for incentives and enforcement**

2.4 • **Current documents governing the participation of participating institutions**
  - **Guidance from higher authorities**
  - **Agreements among participating institutions**

Development, Validation, and Evolution Section of a Technical Architecture

NDRI

3.1 • **Processes**

- **Technical processes involved in the development, validation, and evolution of the technical architecture**
  - » **These might include tests and other methods that address the technical content of the technical architecture**
- **Milestones: approval by Services, defense agencies and OSD**

3.2 • **Roles and duties**

- **OSD: funding and oversight**
- **Participating services and defense agencies**

Maintenance and Maturation Section of a Technical Architecture

NDRI

4.1
- Processes
  - Activities
    - » Assessment
    - » Housekeeping and monitoring
    - » Research and refinement
  - Milestones

4.2
- Roles and duties
  - OSD
  - Participating services and defense agencies
  - Commercial R&D, standards, etc.

Resource Section of a Technical Architecture

NDRI

5.1
- Requirements on the nature and extent of life-cycle management tradeoffs for a weapon system
  - Across weapon systems
  - Across services

5.2
- Approach to obtaining and managing resources required for front-end investments that enable development, validation, evolution, maintenance, maturation, implementation and enforcement of technical architectures

Schedule Section of a Technical Architecture

NDRI

6.1 • Initial establishment of the technical architecture

6.2 • Subsequent maintenance and evolution

6.3 • Resolution of schedule conflicts

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This Section Addresses Methods for Reducing Military Specifications

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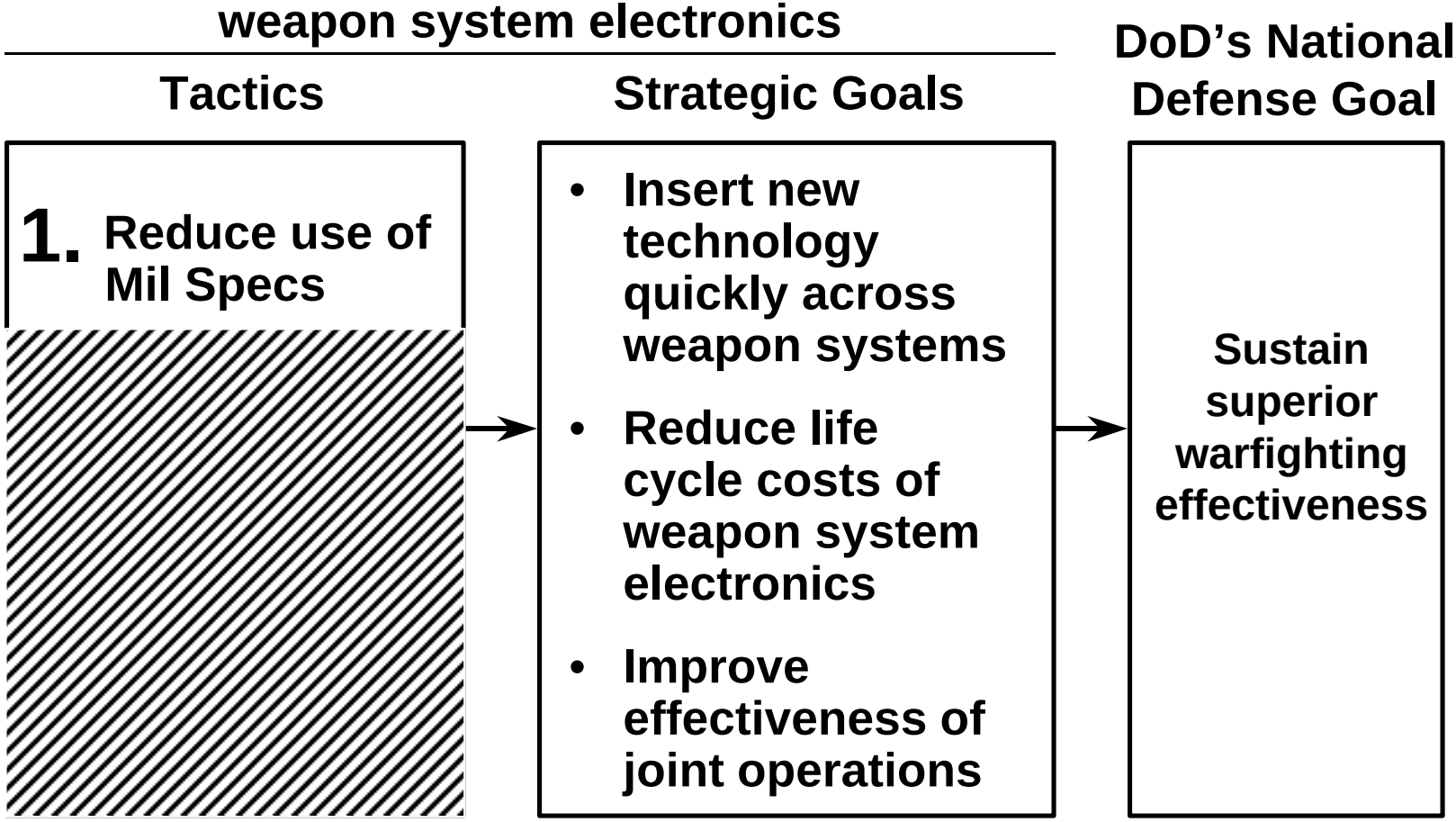
DoD's efforts to improve interoperability of weapon system electronics



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Prospective Method for Reducing Military Specifications

NDRI

- **Research of relevant experience**
- **Prospective technical approach**
- **The JACG business process model**
- **Adapting the business process model**

Overview of the Mil Spec Problem

NDRI

- Role of specifications
  - Communicate buyers needs
  - Basis for factory acceptance
  - Basis for system and qualification testing
- Whats wrong with Mil-Specs
  - Control too much “how to” including materials and processes
  - Seldom updated
  - Are frequently user specific
- What can be used?
  - Commercial specs
  - Military general performance specs
  - Limited application specific performance specs

Note: A performance spec requires a performance attribute, it does not specify how to achieve that attribute (or necessarily how to test it).

Case Studies of Activities Focused Mainly on Reduction of Mil Specs

NDRI

- Joint Aeronautical Commanders Group (JACG)
  - Aeronautical Engineering Board (AEB)
  - Avionics Engineering Sub Board (AESB)
- Generic Open Architecture (GOA)

Prospective Method for Reducing Military Specifications

NDRI

- Research of relevant experience
- Prospective technical approach
- The JACG business process model
- Adapting the business process model

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Reducing Mil Specs Increases Acquisition Flexibility

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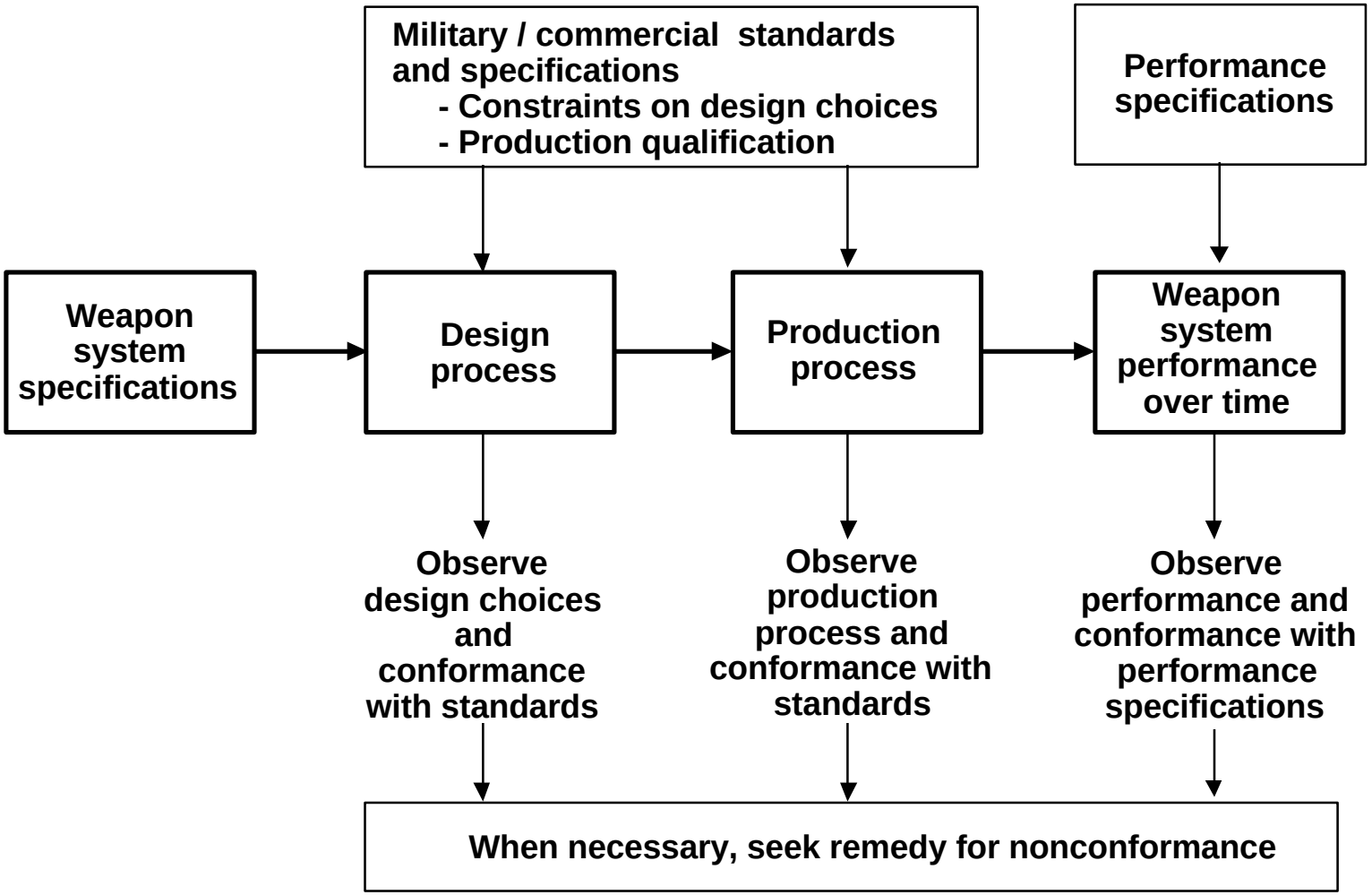

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A Technical Reference Model for the JACG

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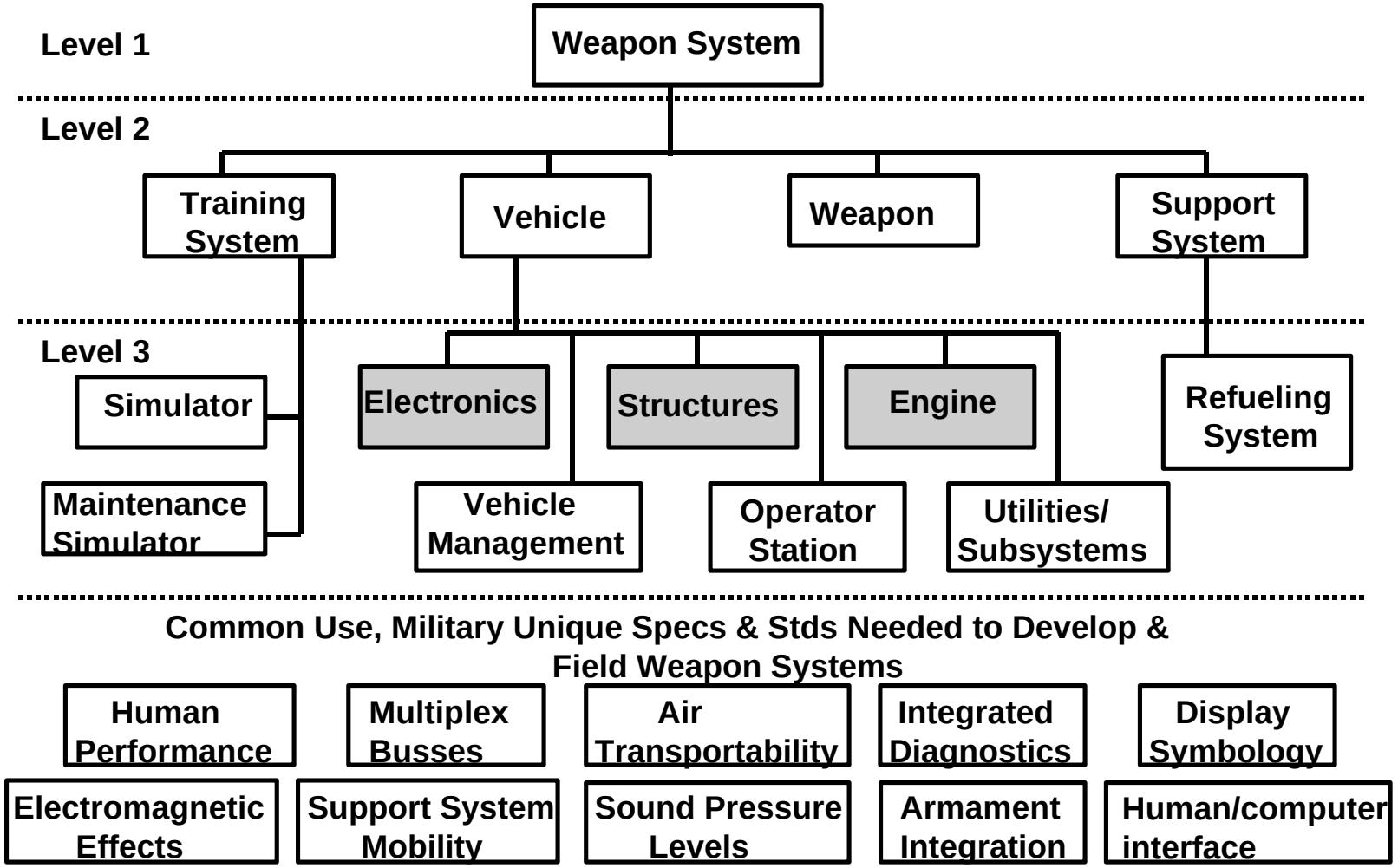

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Requirements for the Methods Used To Reduce Mil Specs (1 of 2)

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- Alternatives to Mil Specs
  - Commercial specifications
  - Performance based specifications
- Analyses of alternatives must consider
  - Life cycle costs
  - Full accounting of support costs
- When eliminating Mil Specs, processes must be established to assure adequate
  - Insertion of design and process requirements in technical data packages
  - Flowdown of specs from level to level
- New specifications must reflect customer needs formerly communicated by Mil-Specs

Requirements for the Methods Used To Reduce Mil Specs (2 of 2)

NDRI

- Contractors must be given flexibility, while the government maintains
  - Minimum essential controls
  - Enough technical data package control to assure openness where cost effective
- Contracts must provide
  - Incentives to reduce Mil Specs
  - Mechanism that assures needed openess

Principles for use of Non Government Standards Developed by the JACG

NDRI

- Complete technical data package is necessary at all levels
- Technical requirements flow down to the lowest level
- Contracts written to encourage prime use of performance based standards
- The build and support packages must have a common technical basis
- Implementation flexibility is critical
- The essential performance attributes of the old Mil Specs need to be in the appropriate specifications
- Control of portions of each level's technical data package driven by program/technical risk
  - Contractors of demonstrated capability given greater authority/responsibility

Technical Data Package (1 of 2)

NDRI

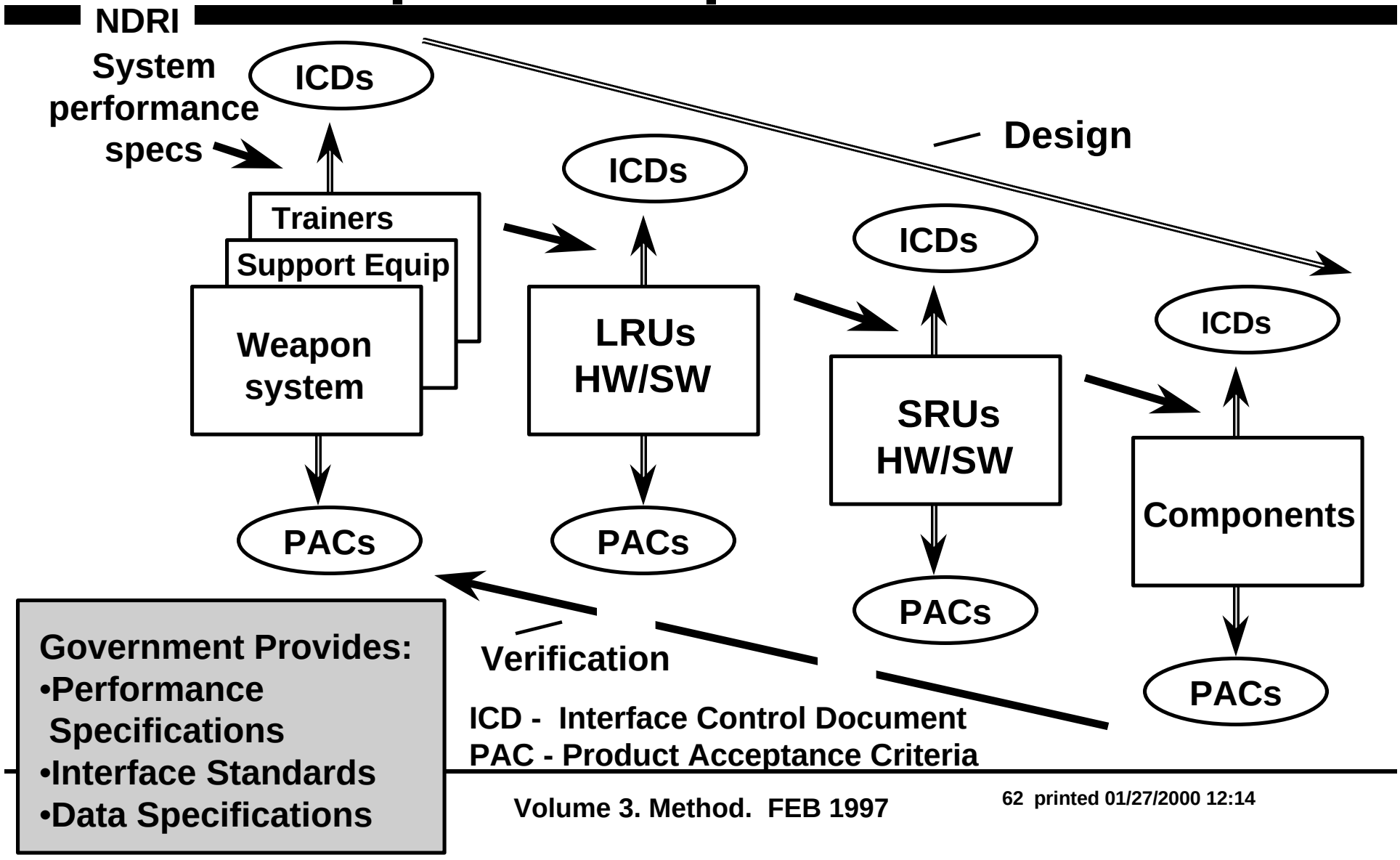
- Allocated functional requirement
- Acceptance criteria
- Interface control document
- Software documentation
  - Language and/or operating system requirements
  - Functional requirements
  - Interface requirements
  - Verification and acceptance requirements
  - Documentation requirements

Technical Data Package (2 of 2)

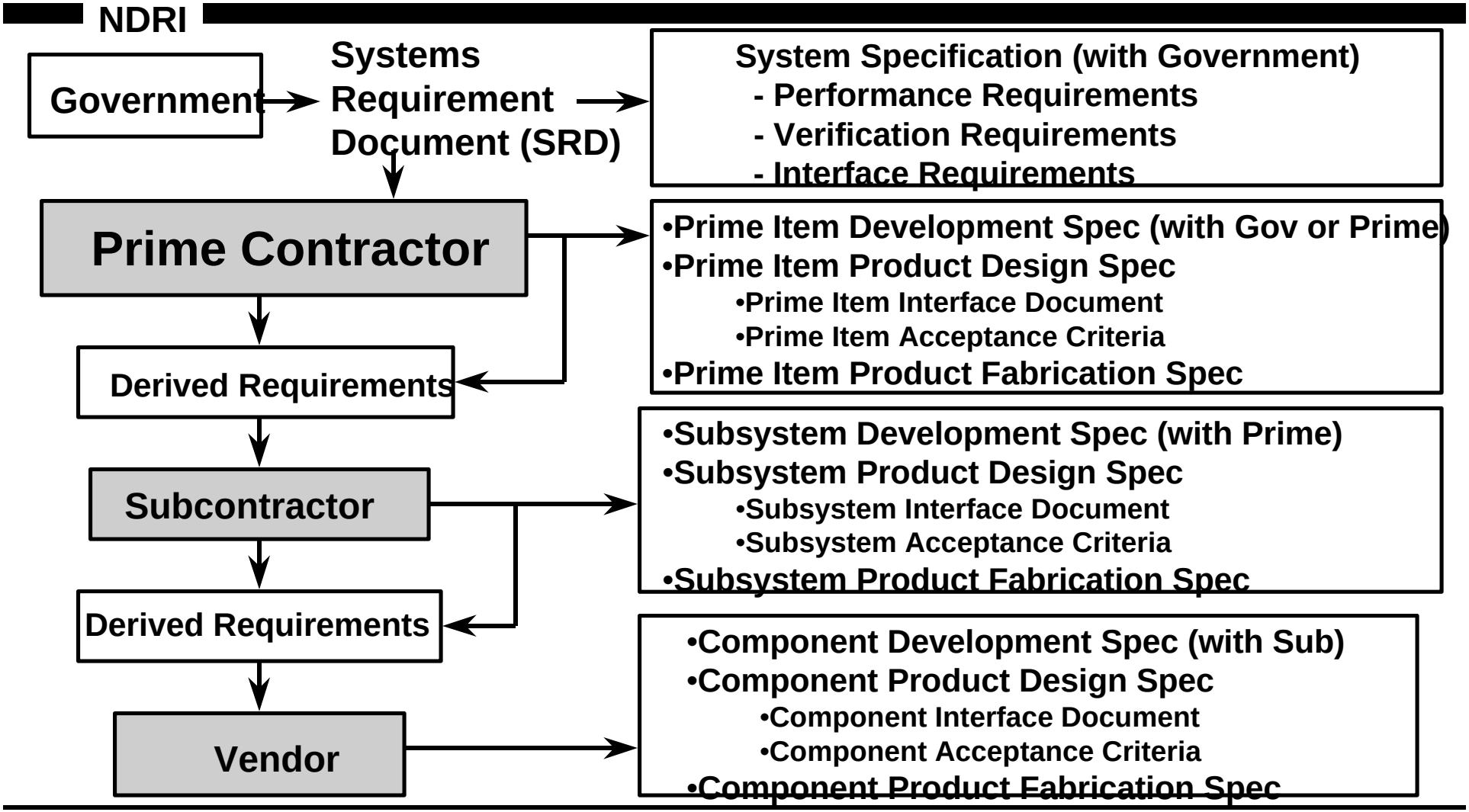
NDRI

- Drawings with tolerances
  - Material Standards
  - Process Standards
  - Physical configuration of item
- Bill of Material
  - Materials including components or assemblies
  - Material Standards
  - Process qualification standards for supplier
  - Acceptance criteria

Flow Down of Design Specs and Buidup of Acceptance Criteria



Prime Contractor Controls Flow Down of Performance Specifications



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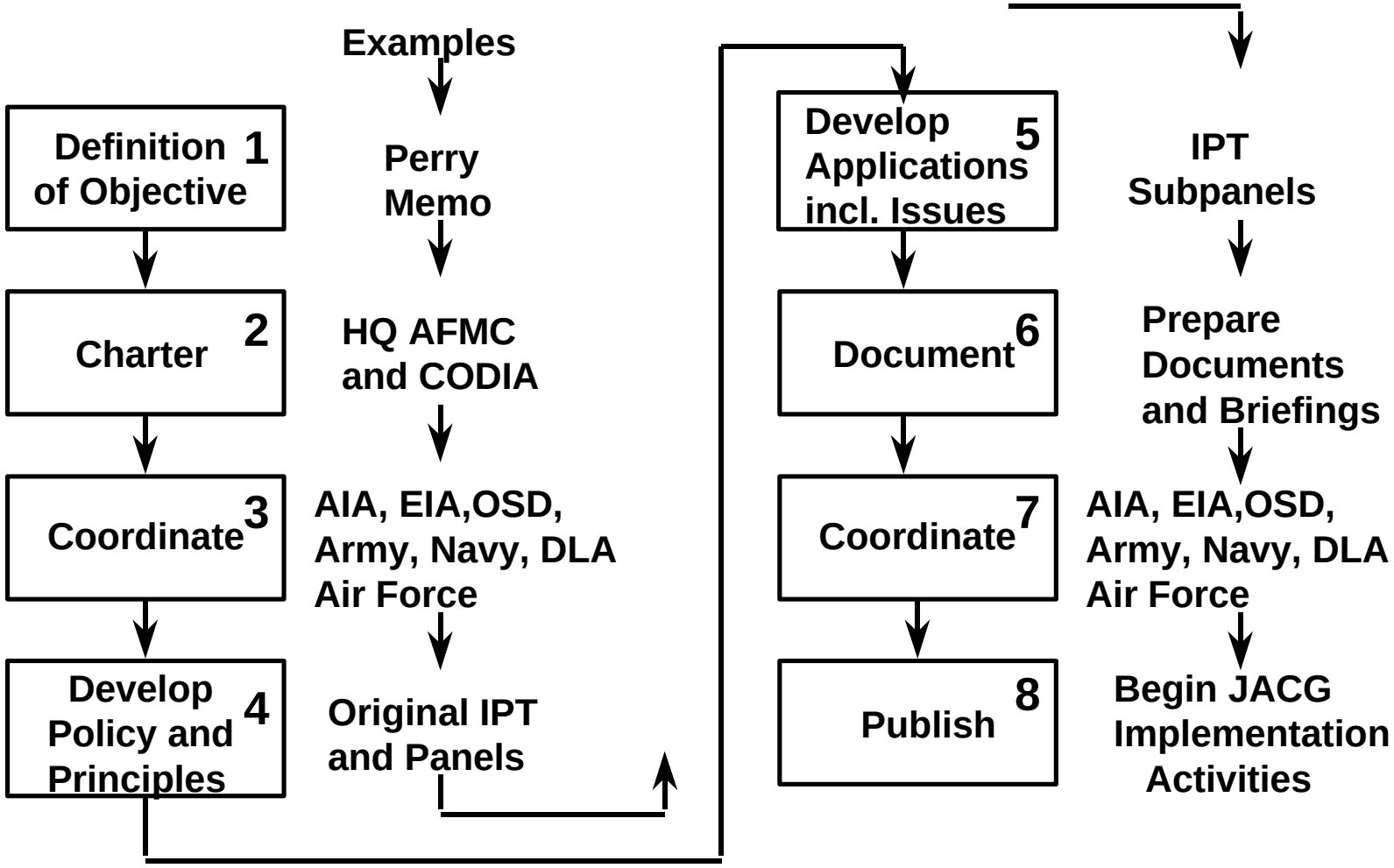
Prospective Method for Reducing Military Specifications

NDRI

- Research of relevant experience
- Prospective technical approach
- **The JACG business process model**
- Adapting the business process model

A Business Process for Developing a Performance-Based Specification System

NDRI



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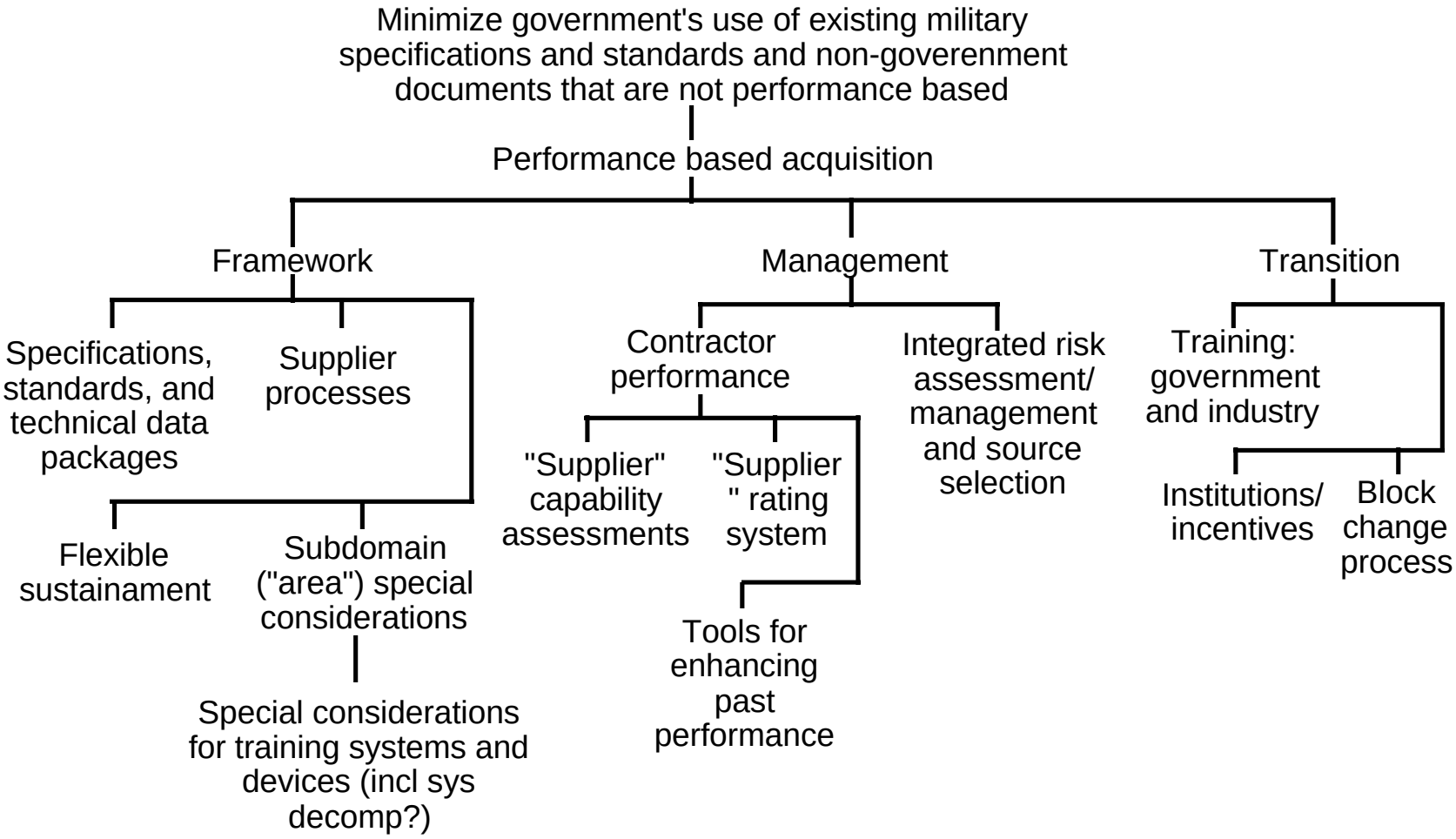
Institutional Factors Addressed by the JACG for Performance Based Specs

NDRI



Prospective Method for Reducing Military Specifications

NDRI

- **Research of relevant experience**
- **Prospective technical approach**
- **The JACG business process model**
- **Adapting the business process model**

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Issues That Need Further Attention

NDRI

- **Depending upon how it is done, reducing Mil Specs may complicate realization**

Suggested Adaptations to the Business Process Model

NDRI

1. Provide for the development of criteria that program offices and prime contractors could use to evaluate the net value of not using military specifications in specific areas
2. Obtain outsource technical assistance
   - Develop criteria for replacing Mil Specs
   - Evaluate applications of the criteria and refine as neeeded
3. Develop principles to be followed by prime contractors in interface development
4. Outsource technical

Why Outside Technical Assistance?

NDRI

- **Technical expertise**
- **Provide “honest broker”**
- **Development continuing relationships**
- **Avoid “procedure based” approach that would repeat the Military Specification problems**

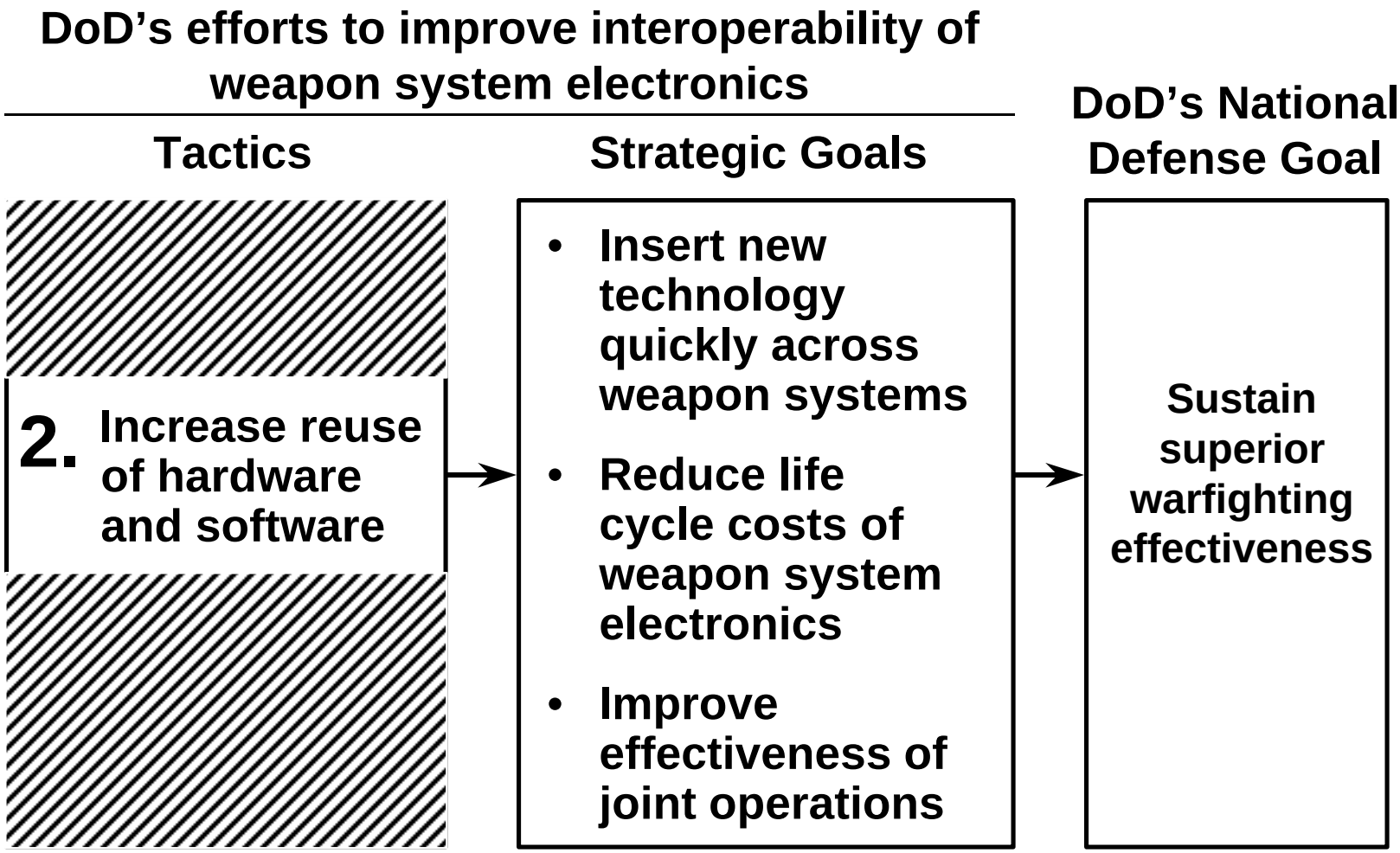
Sections of the Methodology

NDRI

1. Forming the technical architecture concept
2. Dividing electronics into domains
3. Setting the role of a domain's technical architecture
4. Structuring a domain's technical architecture
5. Reducing military specifications
6. Reusing hardware and software
7. Interoperating weapon and C4I systems
8. Coordinating TAs across services/agencies
9. Integrating TAs across domains

This Section Addresses Methods for Increasing Reuse of Electronics

NDRI



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Prospective Method for Reusing Hardware and Software

NDRI

- **Research of relevant experience**
  - **Reuse goals and relevant experiences**
  - **Case studies of relevant experiences**
  - **Experience of the JIAWG**
  - **Experience of ARINC**
- **Prospective technical approach**
- **The ARINC business process model**
- **Adapting the business process model**

Case-Study Objectives for Experiences Relevant To Reuse

NDRI

- Formulate a generic methodology for developing technical architectures aimed at increasing reuse of
  - Commercial hardware and software
  - Defense-peculiar hardware and software
- Explore how to build upon the JACG, AESB, and GOA work to further the reuse of weapon system electronics
- Explore potentially relevant commercial experience (ARINC)

Case Studies of Activities with a Strong Focus on Reuse

NDRI

- **Aviation electronics**
  - **Joint Integrated Avionics Working Group (JIAWG)**
  - **ARINC activities**
  - **Army System of Systems Architecture (ASOSA)**
  - **Generic Open Architecture for AESB**
- **Automatic test equipment**
  - **Modular Automatic Test Equipment Program**
  - **U.S.**

Case Study Initial Findings for Reuse (1 of 2)

NDRI

- To reduce life cycle costs and reduce the time to insert technology by reusing hardware and software, a technical architecture must
  - Specify a common architectural arrangement for the hardware and software to be used in common within the domain
    - » This domain system architecture is part of the technical architecture
  - Specify interfaces for common software
  - Specify interfaces (form, fit, and function) and permissible operating environments for common hardware

Case Study Initial Findings for Reuse (2 of 2)

NDRI

- Application of such a technical architecture may require a front-end investment
  - Trade studies are required to assess the net worth of alternative approaches to the domain's system architecture that is included in the technical architecture
- Technical architectures may differ widely across domains
  - Differences between information systems and weapon systems illustrates the reasons

Value of Common Architectures Depends on the Situation

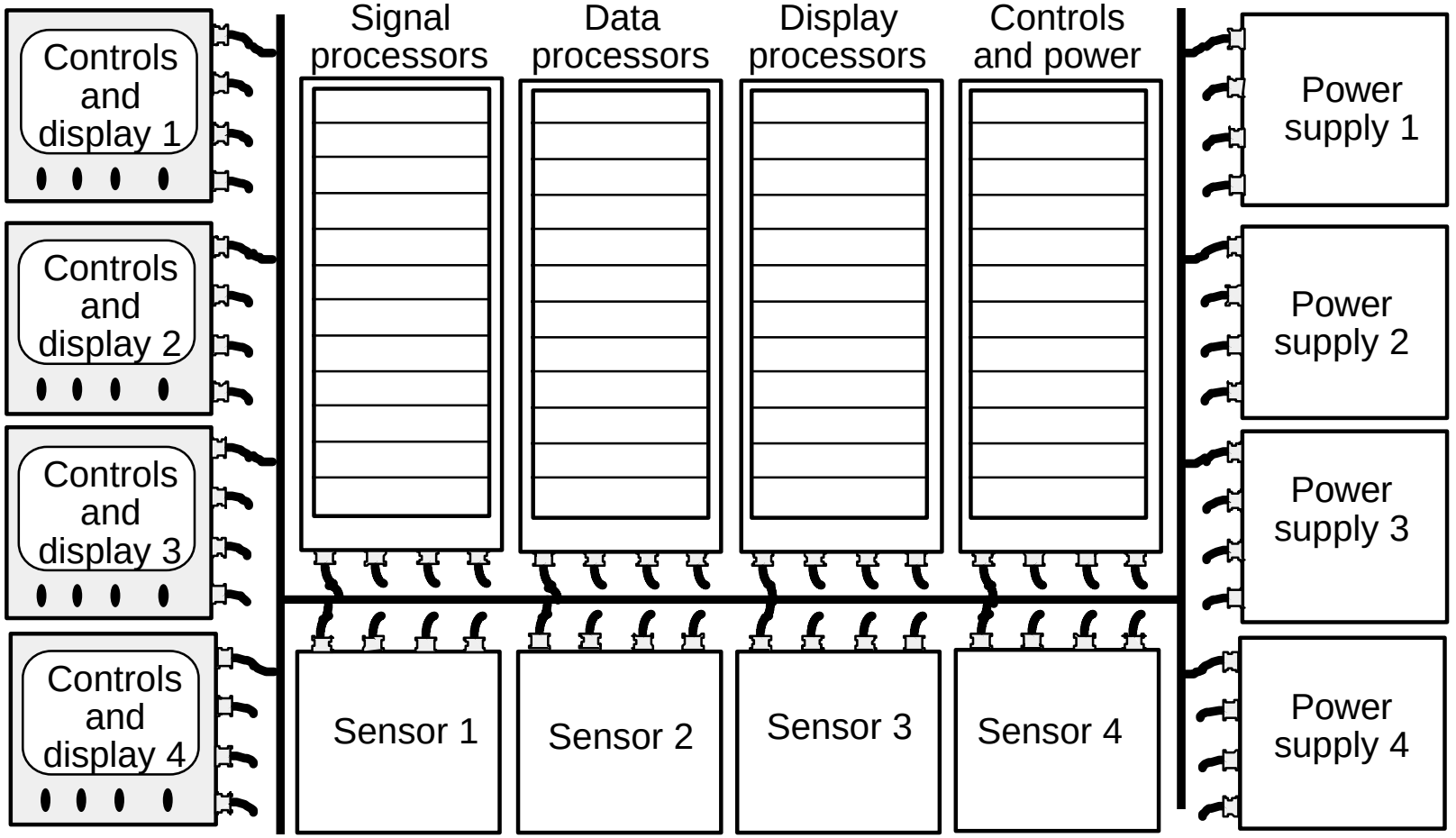
NDRI

- Common architectures provide flexibility
  - But, flexibility costs
  - May or may not be worthwhile depending upon
    - » Extent of flexibility
    - » Situation
- Services need a tradeoff process
- Experience is mixed
  - JIAWG: an initial effort
  - ARINC: a mature approach

The JIAWG Common Architecture

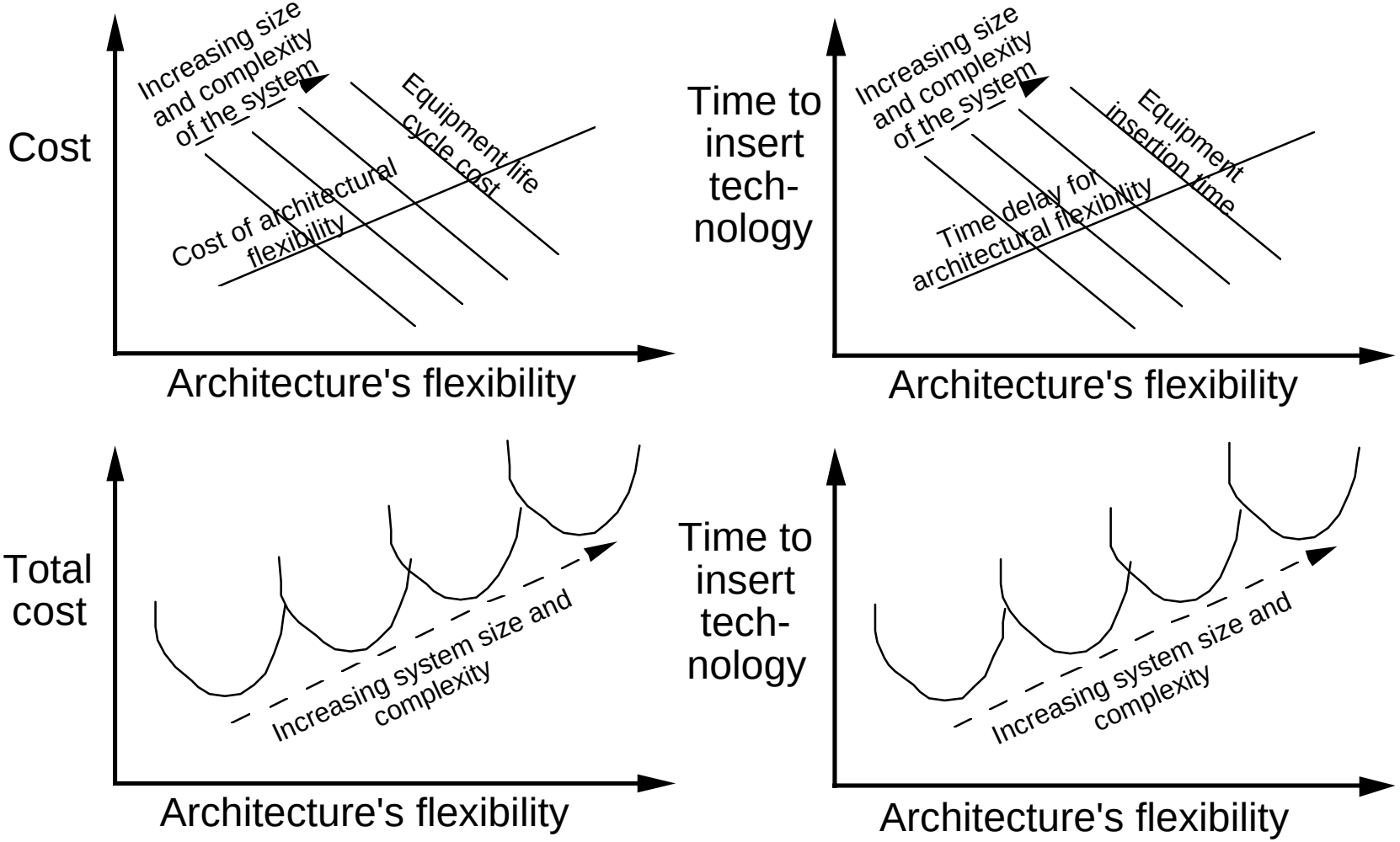
NDRI

Modern Avionics Architecture



Need for Tradeoff Analyses

NDRI



Prospective Method for Reusing Hardware and Software

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  - **Experience of ARINC**
- **Prospective technical approach**
- **The ARINC business process model**
- **Adapting the business process model**

Experience of the Joint Integrated Avionics Working Group (1 of 2)

NDRI

Purpose: use common line replaceable modules across Services

- **Make it easier to mature and support avionics Dissimilar**

Experience of the Joint Integrated Avionics Working Group (2 of 2)

NDRI

- Attempted to standardize across services
  - Standard line replaceable modules (LRMs)
  - Competition and support
  - Protocol issues
  - Environmental control
  - Common architecture - down to common connectors for the operating environment
- Impediment: diverse environment
  - Different vibration spectra led to different designs
- Remaining issues
  - Life-cycle management tradeoffs
    - » Technology insertion
    - » Effectiveness improvement

Prospective Method for Reusing Hardware and Software

NDRI

- **Research of relevant experience**
  - **Reuse goals and relevant experiences**
  - **Case studies of relevant experiences**
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  - **Experience of ARINC**
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- **Adapting the business process model**

ARINC

NDRI

- **Founded in 1929 as wholly**

An Overview of ARINC

NDRI

- **Controlled by the Airlines**
- **Offers**

Significance

NDRI

- **Provides a commercial industry process model for developing “open” specifications for common avionics equipment with reuse and technology benefits.**
- **Experience in “brokering” a specification development process including manufacturers and buyers**
- **Provides an example of a well controlled process that does not use the rigid “military specification” approach**
- **Has both commercial industry and military support experience**
- **Is consistent with the “New Commercial Ways of Doing Business”**

Driving Forces in Industry Are Lacking in the DoD Environment

NDRI

- Airlines want low cost equipment
- Airlines have a clear economic model of their cost structure and a long term interest in it
- Aircraft manufacturers want low avionics and maintenance costs
- Avionics manufacturers want access to as large a market as possible

Prospective Method for Reusing Hardware and Software

NDRI

- **Research of relevant experience**
- **Prospective technical approach**
- **The ARINC business process model**
- **Adapting the business process model**

Approach for Developing a Technical Architecture for Reuse (1 of 5)

NDRI

- Define the weapon systems included in the domain addressed by the technical architecure
- Define
  - Missions performed by the weapon systems in the domain
  - Situations and conditions under which the missions must be performed
    - » Time varying and dynamic through mission phases
    - » Varying across missions

Approach for Developing a Technical Architecture for Reuse (2 of 5)

NDRI

- Define the functions that have to be created, such as
  - Communication
  - Navigation
  - Situation awareness (visual, radar, infrared)
  - Target acquisition
  - Management of stored armament
  - Initialization of armament
  - Steering of armament
  - Housekeeping (e.g., controlling the motion of the weapon system platform)

Approach for Developing a Technical Architecture for Reuse (3 of 6)

NDRI

- Lay out alternative architectures to carry out the functions effectively, while also providing
  - Necessary fault isolation
  - An opportunity to realize the strategic goal(s) most needing increased emphasis in this domain
    - » Partition the system to facilitate attainment, while satisfying other necessary requirements
- Analyze the alternative architectures (in terms of technical, institutional, resource, and schedule aspects)

Approach for Developing a Technical Architecture for Reuse (4 of 5)

NDRI

- Select the architecture(s) for the domain
- Lay out alternative designs for the interfaces to mechanize the architecture
- Analyze the alternatives in terms of technical, institutional, resource, and schedule aspects
- Select the most appropriate interface designs
  - As appropriate, select commercial interface specifications
  - As necessary, develop new interface specifications

Approach for Developing a Technical Architecture for Reuse (5 of 5)

NDRI

- Complete the technical architecture in terms of the sections and subsections defined in Section 4 of the methodology:
  - Section 1. Technical
  - Section 2. Institutional
    - » Including incentives and enforcement
  - Section 3. Development, validation, and evolution
  - Section 4. Maintenance and maturation
  - Section 5. Resources
  - Section 6. Schedule

Guidelines for Developing and Using a TA To Increase Reuse (1 of 2)

NDRI

- Have clear, limited objectives
- Use incentives not mandates

Have clear demarcations

Guidelines for Developing and Using a TA To Increase Reuse (2 of 2)

NDRI

- **Scheduled Technical Milestones**
  - **Technical event to complete tightly defined**
  - **Reasonable but firm schedule**
  - **Responsibility of program manager**

- **Conduct an extensive, continuing test program**
  - **Any development is a learning process**
  - **Learning takes place through test failures**
  - **Funded extensive test program**
    - » **- Saves money**
    - » **- Saves time**
    - » **- Gives high quality**

Prospective Method for Reusing Hardware and Software

NDRI

- Research of relevant experience
- Prospective technical approach
- The ARINC business process model
  - Development of specifications
    - » The ARINC process
    - » Process steps
    - » Process characteristics
  - Products
  - Schedule
- Adapting the business process model

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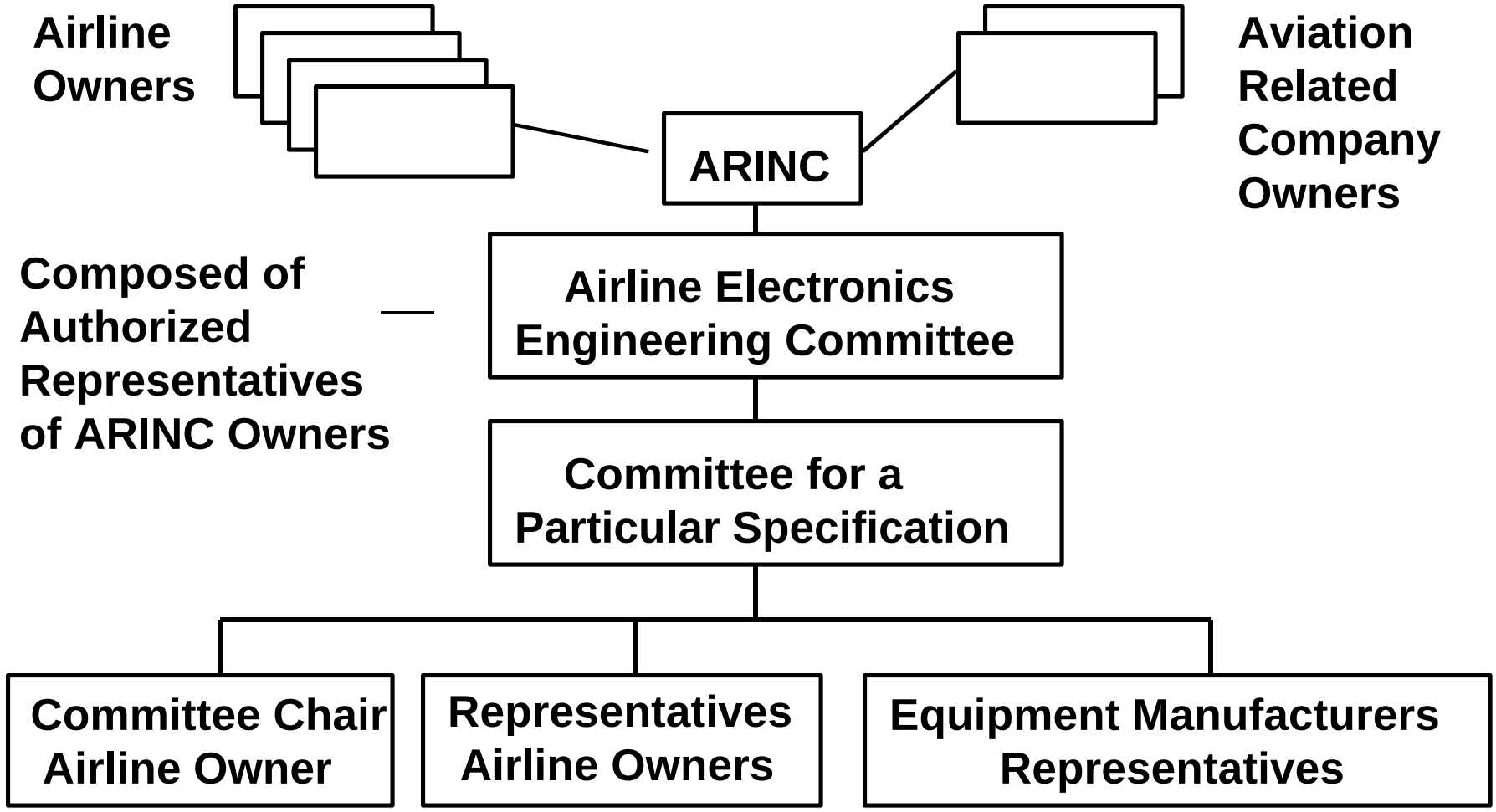
Participants in The ARINC Process for Developing Specifications

NDRI



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Policies for the ARINC Specification Development Process

NDRI

- Established roles for participants
- Chaired by an airline
- Formatted document structure
- Formatted time to develop
- Does not follow “rules” but has established

Roles and Duties of the Participants

NDRI

1 - Specification Committee members have direct interest

2 - Use of “tight” but unwritten document and schedule formats

3 - Specification Committee members can commit their organizations

4 - Analysis of operating savings required before specification work

5 - Compliance relies on economics of process

6 - ARINC takes role as broker, not developer

7 - Economics enforce “long term” view

Steps in the ARINC Process for Developing Specification

NDRI

1. The proposal - specification is suggested
2. The work program - each fall year's work is planned
3. Committee formed - chairman and members of specification committee selected
4. "Strawman" specification developed - circulated with intervening meetings
5. Specification adopted - 2/3 vote of Airline Electronics Committee
6. Final review period - thirty day comment period for any ARINC member, either resolved, or passed by new 2/3 vote

Prospective Method for Reusing Hardware and Software

NDRI

- Research of relevant experience
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- The ARINC business process model
  - Development of specifications
    - » The ARINC process
    - » Process steps
    - » Process characteristics
  - Products
  - Schedule
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Types of ARINC Documents

NDRI

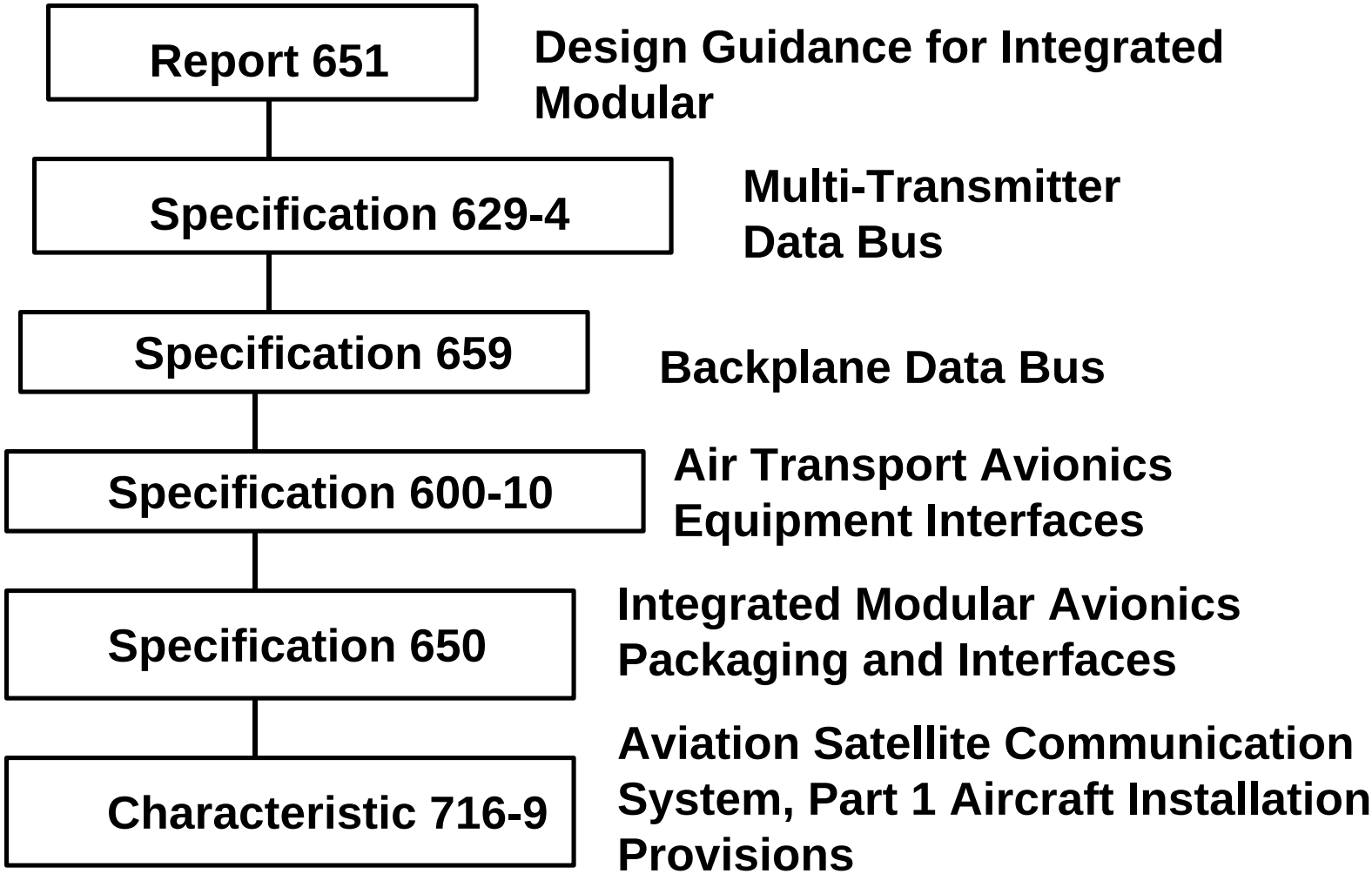
1 - Characteristics Documents - Specify form, fit, and function

2 - Specifications - Give interface specifications and system overview

3 - Reports - Give technical guidance for dealing with generic problems: example, environmental guidelines

Vertical Slice of an ARINC Specification "Tree" Showing the Flow Down of Specs

NDRI



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Some of the ARINC Reports Associated with the Specification "Tree"

NDRI

Report 654	**Environmental Design Guidelines for Integrated Modular Packaging and Interfaces**
Report 652	**Guidance for Avionics Software Development**
Report 624-1	**Design Guidance for Onboard Maintenance System**
Report 660	**CNS/ATM Avionics, Functional Allocation and Recommended Architectures**
Report 602A	**Test Equipment Guidance (TEG)**
Report 625	**Industry Guide for Test Program Set (TPS) Quality Management**

Prospective Method for Reusing Hardware and Software

NDRI

- Research of relevant experience
- Prospective technical approach
- The ARINC business process model
  - Development of specifications
    - » The ARINC process
    - » Process steps
    - » Process characteristics
  - Products
  - Schedule
- Adapting the business process model

Time Frame for Documents

NDRI

- **Nominal - Shoot for one year**
- **Simple may take 3 months, example: Flight Recorder**
- **Complex can be expected to be longer:**
  Modular Avionics took 6 - 7 years

Prospective Method for Reusing Hardware and Software

NDRI

- Research of relevant experience
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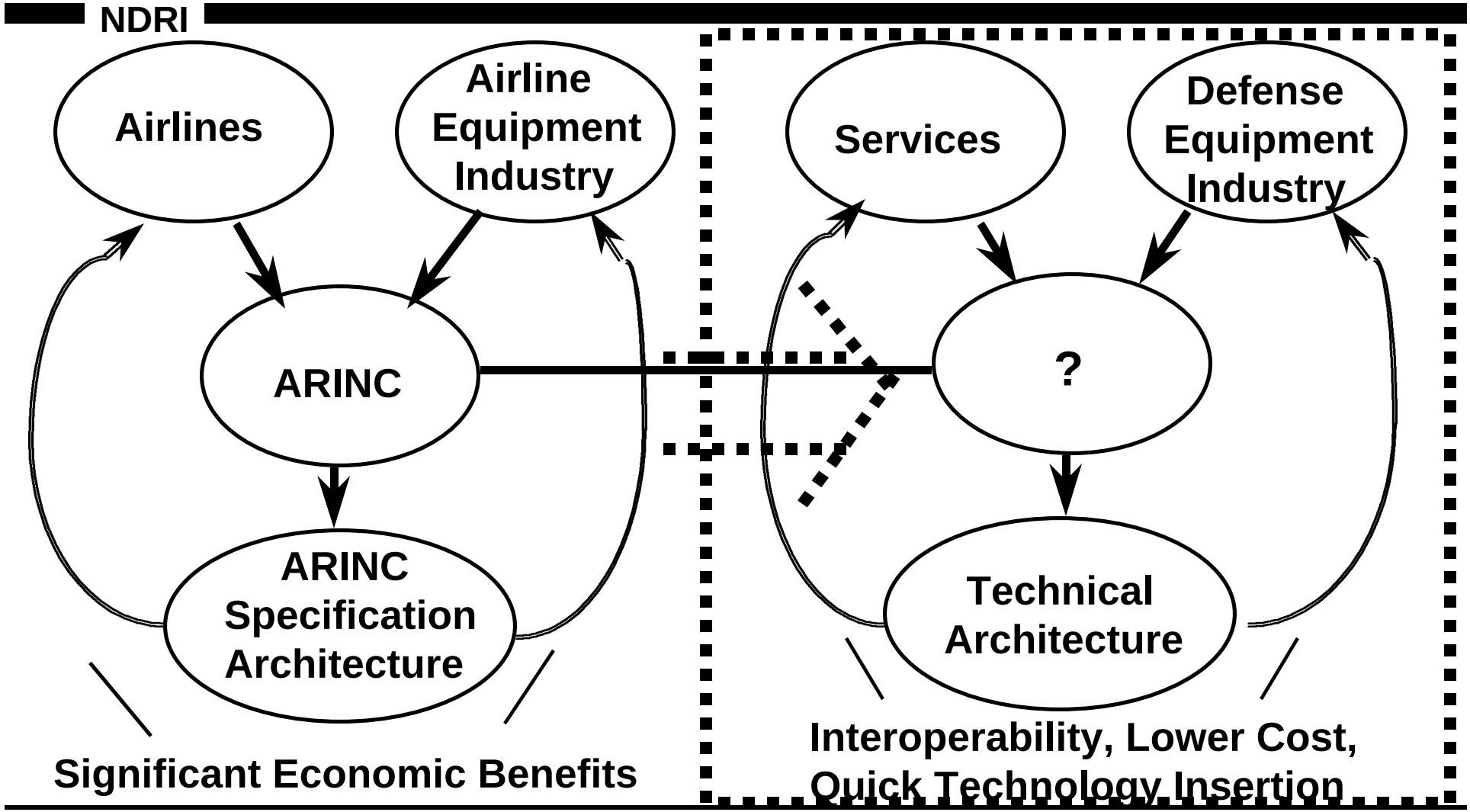
What Should the DOD Counterpart to ARINC Be?



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Challenges in Applying the ARINC Approach to Defense Industry

NDRI

- More Product Lines
- Broader and Many Times More Diverse Environment
- More Technologically Dynamic and Diverse
- Broader Scope
- More Complex Systems
- MORE POLITICS
- MUCH HARDER TO OBSERVE BOTTOM LINE

DoD Actions Needed

NDRI

1. Identify high level “sponsor

Sections of the Methodology

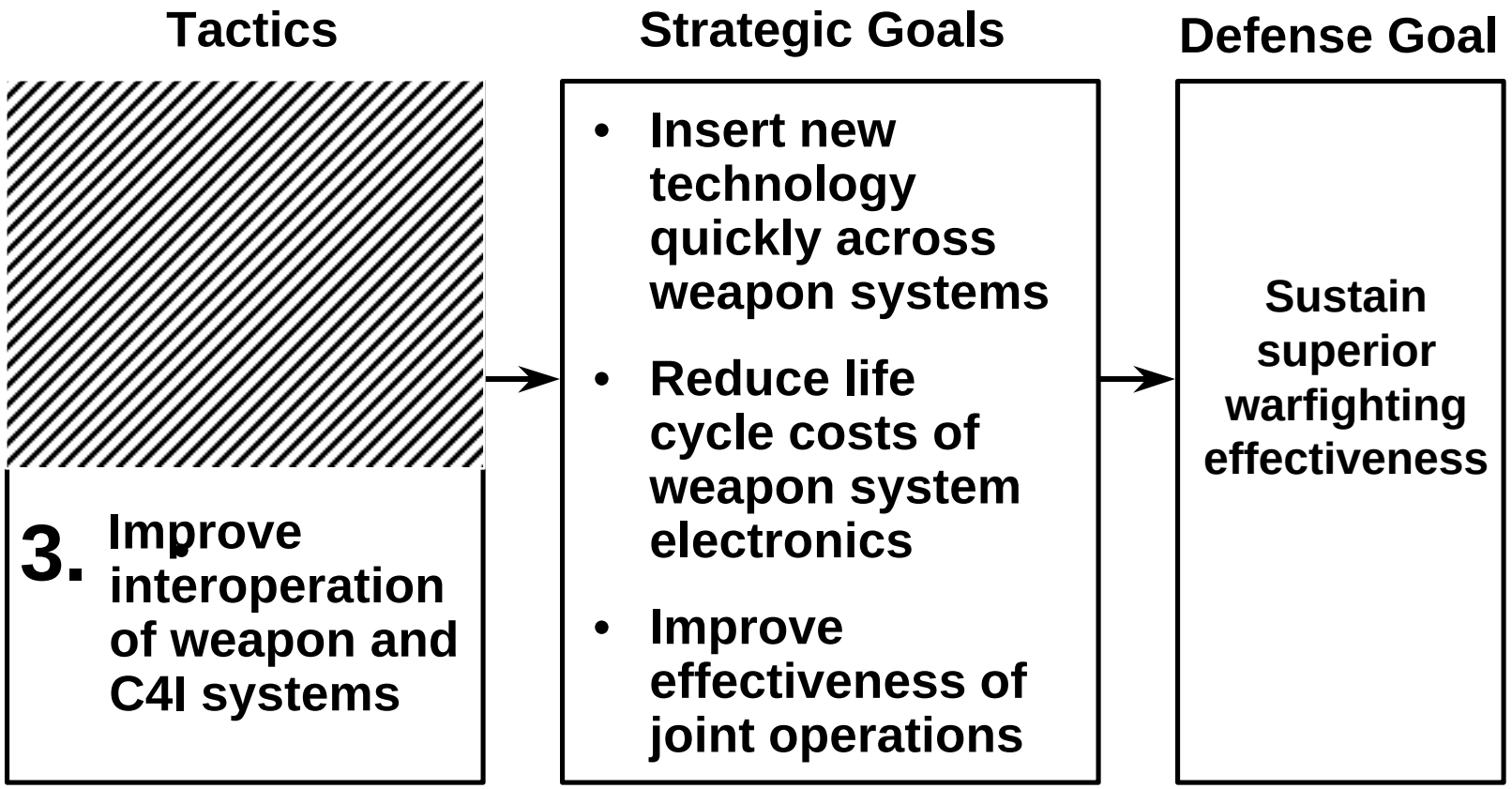
NDRI

1. Forming the technical architecture concept
2. Dividing electronics into domains
3. Setting the role of a domain's technical architecture
4. Structuring a domain's technical architecture
5. Reducing military specifications
6. Reusing hardware and software
7. Interoperating weapon and C4I systems
8. Coordinating TAs across services/agencies
9. Integrating TAs across domains

This Section Addresses Methods for Improving Interoperation

NDRI

DoD's efforts to improve interoperability of weapon system electronics



Prospective Method for Improving Interoperation

NDRI

- **Research of relevant experience**
  - **Overview of the interoperation problem**
  - **Case studies of relevant experiences**
  - **Experience of the ATA**
  - **Experience of the JTA**
- **Prospective technical architecture**
- **The JTA business process model**
- **Adapting the business process model**

The Interoperation Problem for Weapon Systems* (1 of 3)

NDRI

- **Stovepiping of systems**
  - **Few aircraft communicate with ground units, e.g.**
  - **Starts with requirements and includes budgeting, acquisition, and training**
- **Architectures for C2**
  - **Separate for each Service**
  - **No apparent way to integrate**
- **Terminology**
  - **Lack of shared understanding, misuse, and insufficient precision**
  - **Widespread use of "architectures" without rigor needed to convey their meaning consistently**

***Source: C4ISR Task Force (1996), and SAB (1996)**

The Interoperation Problem for Weapon Systems* (2 of 3)

NDRI

- **Communication connectivity**
  - **Incomplete**
  - **Voice oriented**
  - **Doesn't support sharing of sensor data**
- **Missed opportunities**
  - **C3 capabilities have not kept pace with weapon and sensor system technologies**
- **Proliferation of different C3 systems and subsystems within weapon systems**
  - **Inflates development and support costs**
  - **Limits incorporation of new C3 capabilities due to prohibitive modification costs**

***Source: C4ISR Task Force (1996), and SAB (1996)**

The Interoperation Problem for Weapon Systems* (3 of 3)

NDRI

- Current system for developing and fielding command and control systems
  - "Inadequate"
  - "Unacceptable"
- Requirements for weapon system C3 capabilities
  - No standardized, mission-oriented architecture to requirements definition
- Joint Staff lacks abilities to
  - Assure requirements are understood, integrated, and non-duplicative across the DoD
  - Ascertain systems are aligned with joint needs

*Source: C4ISR Task Force (1996), and SAB (1996)

Prospective Method for Improving Interoperation

NDRI

- **Research of relevant experience**
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  - **Case studies of relevant experiences**
  - **Experience of the ATA**
  - **Experience of the JTA**
- **Prospective technical architecture**
- **The JTA business process model**
- **Adapting the business process model**

Case-Study Objectives for Experiences Relevant To Improving Interoperation

NDRI

- **Formulate a generic methodology for developing technical architectures aimed at improving interoperation of weapon and C4I systems**

- **Explore how to extend the technical architecture concept developed for information management systems to weapon system electronics**

Case Studies of Activities Focused Mainly on Improving Interoperation

NDRI

- **Army Technical Architecture (ATA)**
- **Airborne Reconnaissance Information Technical Architecture (ARITA)**
- **Joint Technical Architecture (JTA) and C4ISR Architectural Framework**
- **Technical Architecture for Information Management (TAFIM)**
- **National Institute for Standards and Technology (NIST) Application Portability Profile (APP)**

Case Study Initial Findings for Improving Interoperation

NDRI

- C4I work has focused on information management systems
- Technical architectures for information management systems have focused mainly on software for a domain
  - Do not address domain's architectural style
  - Do not address hardware
  - Do not address implementation issues
    - » Institutional arrangements
    - » Financial aspects
    - » Scheduling matters
  - Such factors must be addressed to complete the implementation of change

Prospective Method for Improving Interoperation

NDRI

- **Research of relevant experience**
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  - **Case studies of relevant experiences**
  - **Experience of the ATA**
  - **Experience of the JTA**
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Development of the Army Technical Architecture for Information Systems

NDRI

- Goals: improve interoperation among information systems, increase reuse of their software, and broaden commercial standards for military use
- Approach: standardize 5 information-system areas
  - Information processing
  - Information transfer
  - Information modeling and data exchange
  - Human computer interfaces
  - Information systems security
- Method:
  - Divide 5 areas into subareas to form a framework
  - Define functional services and interfaces for each subarea and select standards (preferably

Implementation of the Army Technical Architecture (ATA)

NDRI

- **Army Acquisition Executive**
  - **Serves as the ATA Technical Architect**
  - **Supports enforcement of the use of the ATA**
- **Army System Engineer/System Engineering Office**
  - **Reports to the ATA Technical Architect**
  - **Formed group to reach consensus on ATA categories/sub-categories and their standards**
  - **Formed Configuration Control Board, processes and schedules to maintain, mature, and evolve the ATA**
  - **Makes ATA compatible and consistent with JTA and enforces use of ATA**
  - **Oversees implementation of ATA by requiring system migration and transition plans**

Prospective Method for Improving Interoperation

NDRI

- **Research of relevant experience**
  - **Overview of the interoperation problem**
  - **Case studies of relevant experiences**
  - **Experience of the ATA**
  - **Experience of the JTA**
- **Prospective technical architecture**
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Goals for Developing the Joint Technical Architecture (JTA) for C4I

NDRI

- **Provide interoperability among all tactical, strategic and sustaining base systems that produce, use or exchange information electronically**
- **Mandate standards and guidelines to reduce system cost, development and fielding time while minimizing impact on performance wherever possible**
- **Influence direction of information industry's standards-based products**
- **Communicate DoD's intent to use open systems products and implementations to industry**

Development of the Joint Technical Architecture for C4I

NDRI

- **DISA sponsored activity to achieve JTA Version 1.0 in six months**
- **Used ATA as the starting point with strong Service/Agency participation that exploited work and results of many other ongoing related technical efforts within the DoD**
- **Used consensus building technique to decide on standards with established rules for resolving conflicts**

JTA Standards' Selection Criteria (1 of 2)

NDRI

JTA standards are mandated only if they meet the following criteria:

- **Interoperability and/or business case:**
  - **Ensures joint Service/Agency information exchange**
  - **Supports joint (and potentially combined) C4I operations**
  - **And/or provides strong economic justification**
    - » **Absence of a mandated standard will result in increased life-cycle costs**

JTA Standards' Selection Criteria (2 of 2)

NDRI

- **Maturity: They are technically mature and stable**
- **Implementability: They are technically implementable**
- **Public: They are publicly available (e.g., open systems standards)**
- **Consistent with Authoritative Sources: They are consistent with law, regulation, policy, and guidance documents**

JTA Implementation, Evolution and Configuration Management

NDRI

- **Implementation guidance was provided in an August 1996 DoD Memorandum**

Acquisition Executives are responsible

Prospective Method for Improving Interoperation

NDRI

- Research of relevant experience
- Prospective technical architecture
- The JTA business process model
- Adapting the business process model

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Scope of Activities Addressed by the Technical architecture

NDRI

- Addresses interoperation at the force and mission level
  - At force level: between weapon system(s) and C4I system(s)
  - At mission level: between weapon systems
- Supports
  - Platform operation
  - Weapon system lethality and countermeasure functions
  - Payload functions

Develop a Technical Architecture for Improving Interoperation (1 of 2)

NDRI

1. • Identify information-interchange requirements for the domain's As-Is state
2. • Identify information-interchange requirements for the domain's To-Be states
3. • Combine information-interchange requirements for domain's As-Is and To-Be states
4. • Select/develop interface standards for information-interchange requirements
5. • Reconcile selected standards with the JTA for C4I information management systems

Develop a Technical Architecture for Improving Interoperation (2 of 2)

NDRI

For the domain's To-Be states

6. • **Develop equipment migration plans to satisfy requirements**
7. • **Modify weapon system program management plans to include migration plans**
8. • **Modify weapon system budget plans to reflect migration plans**
9. • **Reconcile weapon system management and budget plans to assure synchronized migration**
10. • **Update the technical architecture to reflect migration plans and cooperative efforts**

1. Define information interchange requirements for Domain's As-Is State

NDRI

For the domain's As-Is state

- **1.1** • **Construct the operational architecture**
- **1.2** • **Construct the system architecture**
- **1.3** • **Define the information interchange requirements**
- **1.4** • **Develop a list of information interchange requirements**

1.1 Construct the Operational Architecture for Domain's As-Is State

NDRI

- **Inputs**
  - **Domain specific**
  - **Warfighters**
  - **Other weapon system specific inputs**
- **Products**
  - **Operational architecture for each weapon system's As-Is state**
  - **Operational architecture for domain's As-Is state**
  - **Documentation of As-Is operational architecture detail**
- **Verification of domain As-Is operational architecture product information**

1.2 Construct the System Architecture for Domain's As-Is State

NDRI

- **Inputs**
  - **Domain specific**
  - **Service/Agency/warfighter inputs**
  - **Weapon system specific inputs**
- **Products**
  - **Weapon system As-Is System Architecture for each weapon system in domain**
  - **Domain As-Is System Architecture (system architecture)**
  - **Documentation of As-Is system architecture detail for domain**
- **Verification of As-Is system architecture domain product information**

1.3 Define the information interchange requirements for Domain's As-Is State

NDRI

- **Inputs**
  - **Operational architecture for domain's As-Is state**
  - **System architecture for domain's As-Is state**
- **Method: for each weapon system in the domain**
  - **Examine every link between the weapon system and other weapon systems and C4I systems**
  - **Define each information interchange**
- **Output**
  - **Consolidated statement of the information interchange requirements for the domain's As-Is state**

1.4 Categorize the Information-Interchange Requirements

NDRI

- Classify the information interchange requirements into the categories used in the JTA (if appropriate)
  - Categories of main interest will be: Data Interchange, Information Standards (covers tactical message system systems), Communications, Operating System Services
- For information interchange requirements not classified in terms of JTA categories
  - Review domain technical architectures for weapon system electronics for appropriate category and use if found
  - If not found, define new category
- Product: matrix of categories and information interchange requirements that fall in the categories

2. Define information interchange requirements for Domain's To-Be States

NDRI

For the domain's To-Be states

- **2.1** • **Construct the operational architecture**
- **2.2** • **Construct the system architecture**
- **2.3** • **Define the information-interchange requirements**
- **2.4** • **Categorize the information-interchange requirements**

2.1 Construct the Operational Architectures for Domain's To-Be States

NDRI

- **Inputs**
  - **Domain specific**
  - **Warfighters**
  - **Other weapon system specific inputs**
- **Products**
  - **Operational architectures for weapon system's To-Be states**
  - **Operational architectures for domain's To-Be states**
  - **Documentation of system architectures for domain's To-Be states**
- **Verification of To-Be operational architecture product information for domain**

2.2 Construct the System Architectures for Domain's To-Be States

NDRI

- **Inputs**
  - **Domain specific**
  - **Service/Agency/warfighter inputs**
  - **Weapon system specific inputs**
- **Products**
  - **Weapon system To-Be system architecture for each weapon system in domain**
  - **Domain To-Be system architecture (system architecture)**
  - **Documentation of To-Be system architecture for domain**
- **Verification of To-Be system architecture product information for domain**

2.3 Define the information interchange requirements for Domain's To-Be States

NDRI

- **Inputs**
  - **Operational architecture for domain's As-Is state**
  - **System architecture for domain's As-Is state**
- **Method: for each weapon system in the domain**
  - **Examine every link between the weapon system and other weapon systems and C4I systems**
  - **Define each information interchange**
- **Output**
  - **Consolidated statement of the information interchange requirements for the domain's As-Is state**

2.4 Categorize the Information-Interchange Requirements

NDRI

- **Classify the information interchange requirements into the categories used in the JTA (if appropriate)**
  - **Categories of interest: Data Interchange, Information Standards (covers tactical message system systems), Communications, Operating System Services**
- **For information interchange requirements not classified in terms of JTA categories**
  - **Review all weapon system Domain TAs for appropriate category and use if found**
  - **If not found, define new category**
- **Product: matrix of categories and information interchange requirements that fall in the categories**

3. Combine information interchange requirements for Domain's States

NDRI

- **Combine the As-Is and To-Be information interchange requirements into one matrix of requirements**

4. Select/Develop Interface Standards for information interchange requirements

NDRI

- 4.1 • Set up technical architecture using categories in the JTA and a new hardware interface category
- 4.2 • Lookup information interchange requirements in all relevant, existing TAs for relevant rules and standards and enter those in the respective area of the domain technical architecture
- 4.3 • Handle information interchange requirements for which rules and standards cannot be found in existing TAs
- 4.4 • Assess benefits and costs of adopting each standard
- 4.5 • Adopt most worth while standards

4.3 Handle Cases for Which Rules and Standards Cannot be Found in Existing TAs

NDRI

- **Information interchange requirements for which rules and standards cannot be found:**
  - **a. New information interchange requirement for which there are existing or emerging commercial standards that do not appear in existing TAs**
  - **b. New information interchange requirement covered by emerging JTA or other domain technical architectures standard**
  - **c. New information interchange requirement for which there are no existing or emerging commercial standards that do not appear in the existing TAs**

5. Reconcile the Domain's Standards with the JTA

NDRI

- Information processing
- Information transfer
- Information modeling and information
- Human-computer interfaces
- Information systems security

Develop a Technical Architecture for Improving Interoperation (2 of 2)

NDRI

For the domain's To-Be states

6. • **Develop equipment migration plans to satisfy requirements**
7. • **Modify weapon system program management plans to include migration plans**
8. • **Modify weapon system budget plans to reflect migration plans**
9. • **Reconcile weapon system management and budget plans to assure synchronized migration**
10. • **Update the technical architecture to reflect migration plans and cooperative efforts**

6. Develop Equipment Migration Plans to Satisfy Requirements

NDRI

- **6.1** • **Define equipment (HW and SW) replacement/modification requirements**
- **6.2** • **Identify the worthwhile opportunities for reuse**
  - **6.2.1** – **Find reuse opportunities by analyzing information interchanges**
  - **6.2.2** – **Find reuse opportunities by examining communications interfaces**
  - **6.2.3** – **Analyze the costs and benefits of pursuing reuse opportunities**
- **6.3** • **Develop and implement a program for reuse**
  - – **Use section 8 of the methodology**
- **6.4** • **Develop a comprehensive migration plan for the domain's To-Be states**

6.2.1 Find Reuse Opportunities by Analyzing Information-Interchanges

NDRI

Things to look for:

- **Weapon system sending or receiving same or similar information to other external systems**
- **Weapon system domain system architecture indicating multiple weapon systems in domain sending same/similar information to other systems**
- **Domain system Architecture indicating multiple weapon systems in domain receiving same/similar information from other systems**
- **Domain weapon systems interchanging data with other systems using the same message systems, investigate possibility for commonality of message system software and/or communications hardware**

6.2.2 Find Reuse Opportunities by Examining Communications Interfaces

NDRI

- **Software reuse possibilities for military message system systems**
  - **Common message system processing software for composing message systems to send and parsing received message systems (part of DII/COE common applications)**
  - **Extension of commonality by using data standards and a standards-based database across all systems using military message system systems**

- **Reuse of common hardware devices/interfaces for communications**

7. Modify Weapon System Program Management Plans to Include Migration Plans

NDRI

- **Input: migration plans for domain's To-Be states with required dates for**
  - **Initial operational capability (IOC)**
  - **Full fielding of operational capability**
- **Method: weapon system program managers**
  - **Modify program management plans**
  - **Incorporate sufficient provisions for research, development, test and evaluation, and production/modification to meet requirements of domain's To-Be states**
  - **Secure approval of Service/agency acquisition executive**
- **Output: Service/agency approved**
  - **Weapon system program management plans**

8. Modify Weapon System Budget Plans to Reflect Migration Plans

NDRI

- **Input: Service/agency approved program management plans**
- **Method: Weapon system program managers**
  - **Estimate funding requirements to support the migration plans for the domain's To-Be states**
  - **Modify program budget**
  - **Modify program inputs to the POM and PPBS**
  - **Secure support for modified budget**
    - » **Weapon system's using command**
    - » **Service/agency deputy chief of staff for operations**
    - » **Combatant CINCs and Joint Staff**
    - » **Service/agency acquisition executive**
- **Output: Service/agency approved funding**
  - **Planned, programmed, and budgeted**

9. Reconcile Weapon System Management and Budget Plans with Joint Migration

NDRI

- **Input: for each weapon system in the domain**
  - **Program management plan**
  - **Service/agency approved budget plans**
- **Method: Domain Technical Architecture Committee**
  - **Assesses ability of program management plans and program budgets to support migration plans for domain's To-Be states**
  - **Identifies inconsistencies and risks**
  - **Identifies preferred and alternate corrective actions**
- **Output: identification of implementation issues**
  - **Nature and implications**
  - **Options for adjusting migration/program plans**

10. Update Technical Architecture to Reflect Migration Plans and Joint Efforts

NDRI

- **Input: reconciliation of weapon system program and budget plans**
- **Method: Domain Technical Architecture Committee**
  - **Updates the resource and schedule sections of the technical architecture**
  - **As necessary, revises**
    - » **Economic analyses**
    - » **Domain's To-Be states to reflect funding and schedule constraints**
    - » **Technical section of the technical architecture**
- **Output: Revised technical architecture**
  - **Reflects current knowledge of fiscal and schedule constraints**

Prospective Method for Improving Interoperation

NDRI

- **Research of relevant experience**
- **Prospective technical architecture**
- **The JTA business process model**
- **Adapting the business process model**

JTA Business Process Model

NDRI

- Assign institutional authority and responsibility at high level in organization
- Establish well defined objectives
- Establish well defined criteria for mandating standards
- Establish well organized JTA development working group with representatives from all relevant organizations that can tap their organization SMEs and represent their organization's position
- Institutionalize policies and procedures for JTA implementation, enforcement, evolution and configuration management

Prospective Method for Improving Interoperation

NDRI

- **Research of relevant experience**
- **Prospective technical architecture**
- **The JTA business process model**
- **Adapting the business process model**

Adapting the JTA Business Process Model

NDRI

Domain technical architecture

- High level institutional authorities: extend to include domain managers
- Objectives and standards selection criteria: no change from JTA
- Categories: expand on JTA categories to include hardware interfaces
- Domain working group: different process from JTA
- Implementation, enforcement, evolution, and configuration management: include role of domain manager

JTA Related Issues (1 of 2)

NDRI

- Lack of warfighter guidance as to how the U.S. plans to fight in the future (the To-Be Operational Architecture)
  - Impedes intelligent choice in supporting emerging technologies, standards, etc.
  - Impedes cost benefit trade offs for system migrations to JTA standards, especially emerging standards
- Lack of synchronization of migration plans across Services/agencies could
  - Negatively affect Joint Task Force operations
  - Inefficiently apply DoD funds

JTA Related Issues (2 of 2)

NDRI

- Need more research on how to evolve warfighting systems as standards evolve: ability to maximize use of new technology while minimizing mismatches due to asynchronous implementations
- DII/COE
  - Based on specific hardware platforms and software systems
  - Lack of attention to evolutionary change
- Need to research how to integrate the multitude of stove-piped DoD message system systems

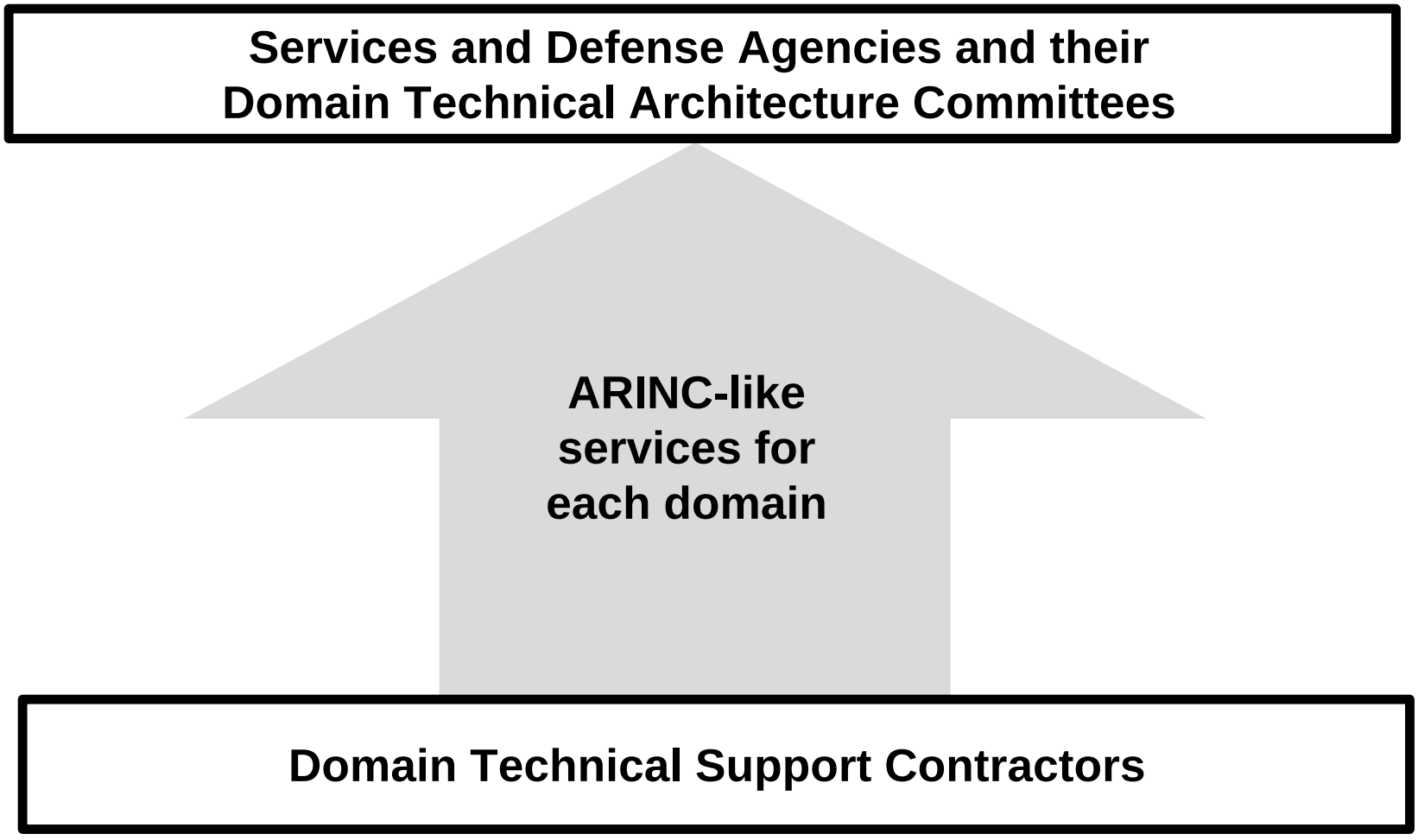
Sections of the Methodology

NDRI

1. Forming the technical architecture concept
2. Dividing electronics into domains
3. Setting the role of a domain's technical architecture
4. Structuring a domain's technical architecture
5. Reducing military specifications
6. Reusing hardware and software
7. Interoperating weapon and C4I systems
8. Coordinating TAs across Services/agencies
9. Integrating TAs across domains

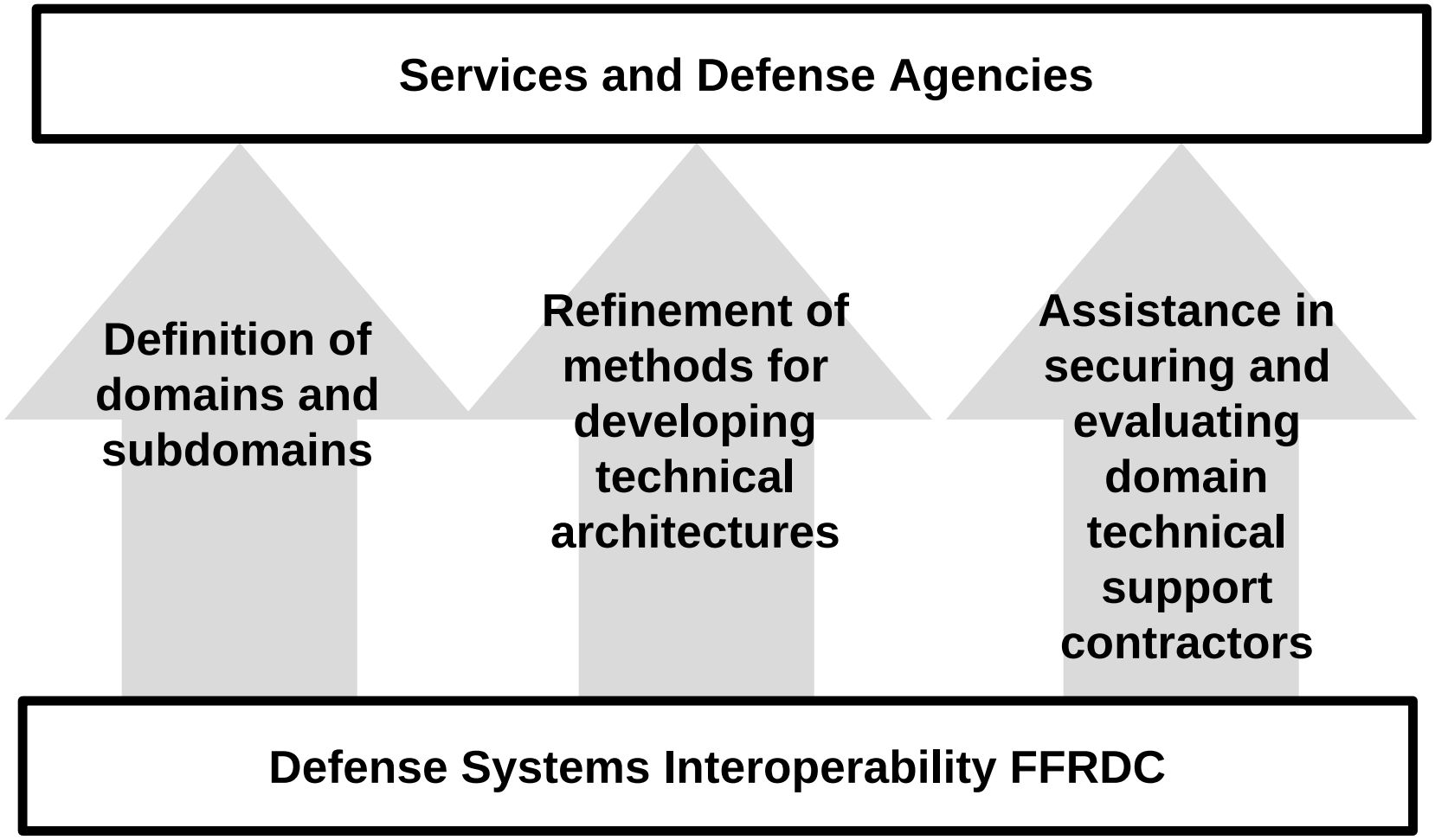
Technical Support Contractors Assist the Services and Defense Agencies

NDRI



An Interoperability FFRDC Also Assists the Services and Agencies

NDRI



Coordinating Technical Architectures Across Services/Agencies

NDRI

- **Option 1, bottom-up**
- **Option 2, top down**

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Option 1, Bottom-Up Coordination of TAs Across Services and Agencies

NDRI

- For each domain/subdomain, establish a mechanism for bottom-up governance
  - Designate a lead service
  - Form a Domain Technical Architecture Committee with a strong leader
- Motivate the DTAC
  - Hold service/agency acquisition executives responsible for building and using TAs
  - Provide acquisition executives authority to task their service/agency acquisition organizations
- Provide tecnical support at each level
  - FFRDC support to acquisition executives
  - ARINC-like support to each domain

Coordinating Technical Architectures Across Services/Agencies

NDRI

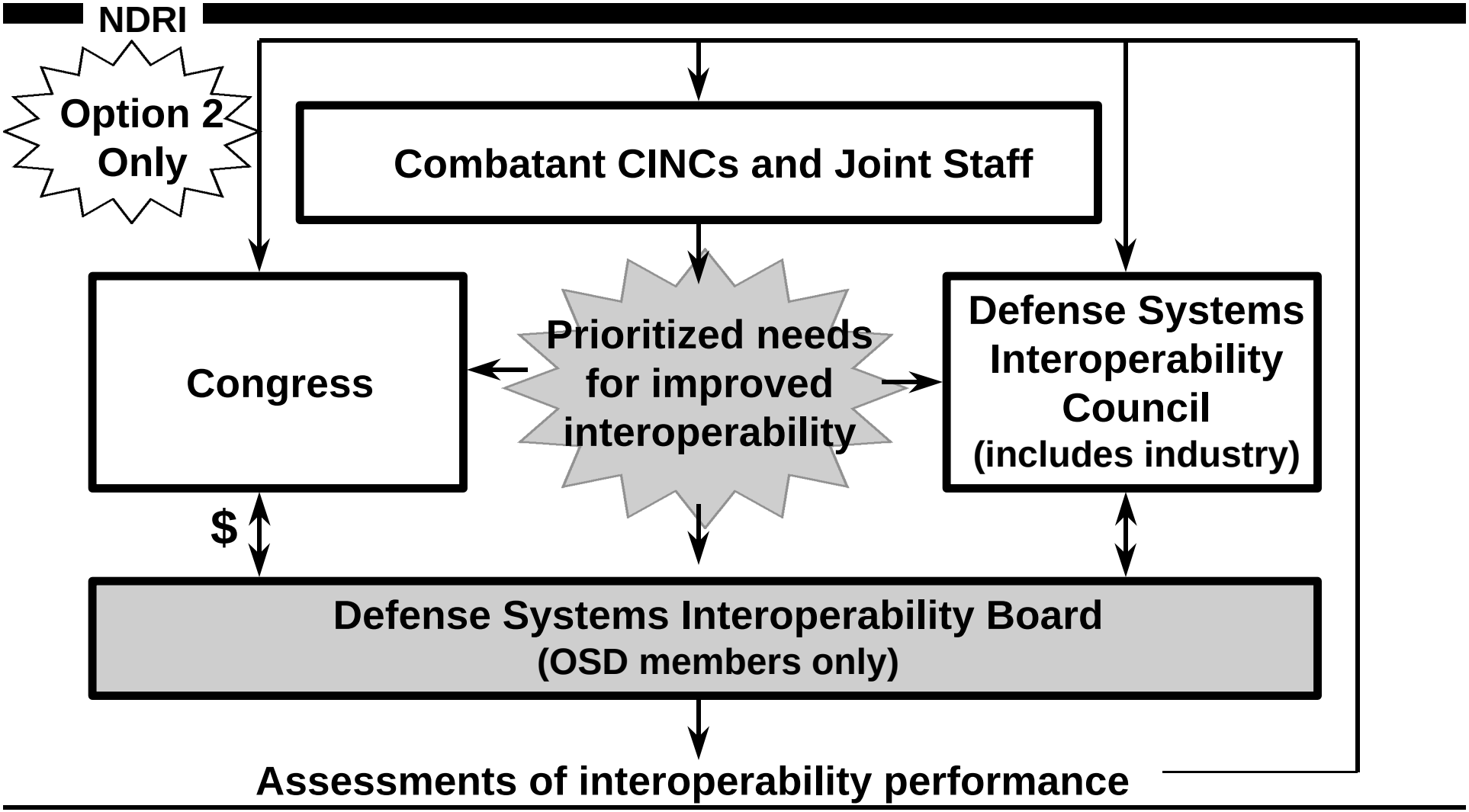
- **Option 1, bottom-up**
- **Option 2, top down**

Option 2, Top-Down Concept for Integrating Across Services and Agencies

NDRI

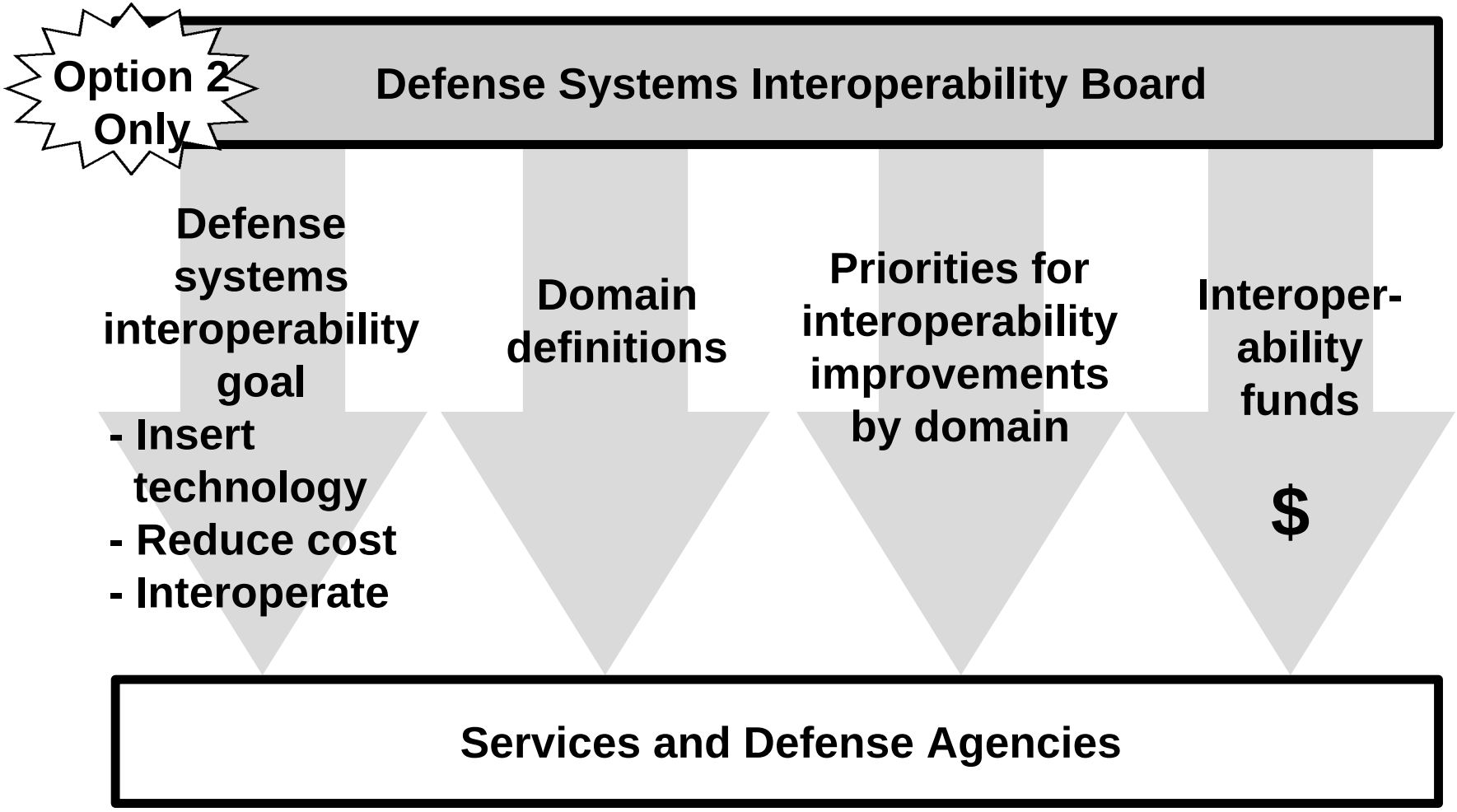
- **Establish a mechanism for top-level guidance**
  - **Form a Defense Systems Interoperability Board (DSIB) with OSD members only**
  - **Form a Defense Systems Interoperability Council that includes industry**
- **Empower the DSIB**
  - **Distribution of interoperability funds**
  - **Review of domain technical architectures**
  - **Role in milestone decisions for acquisition programs**
- **Provide technical support at each level**
  - **FFRDC support to DSIB, services and agencies**
  - **ARINC-like support to each domain**

Combatant CINCs, the Joint Staff, Congress, and Industry Guide the DSIB



The DSIB Guides the Services and Defense Agencies

NDRI



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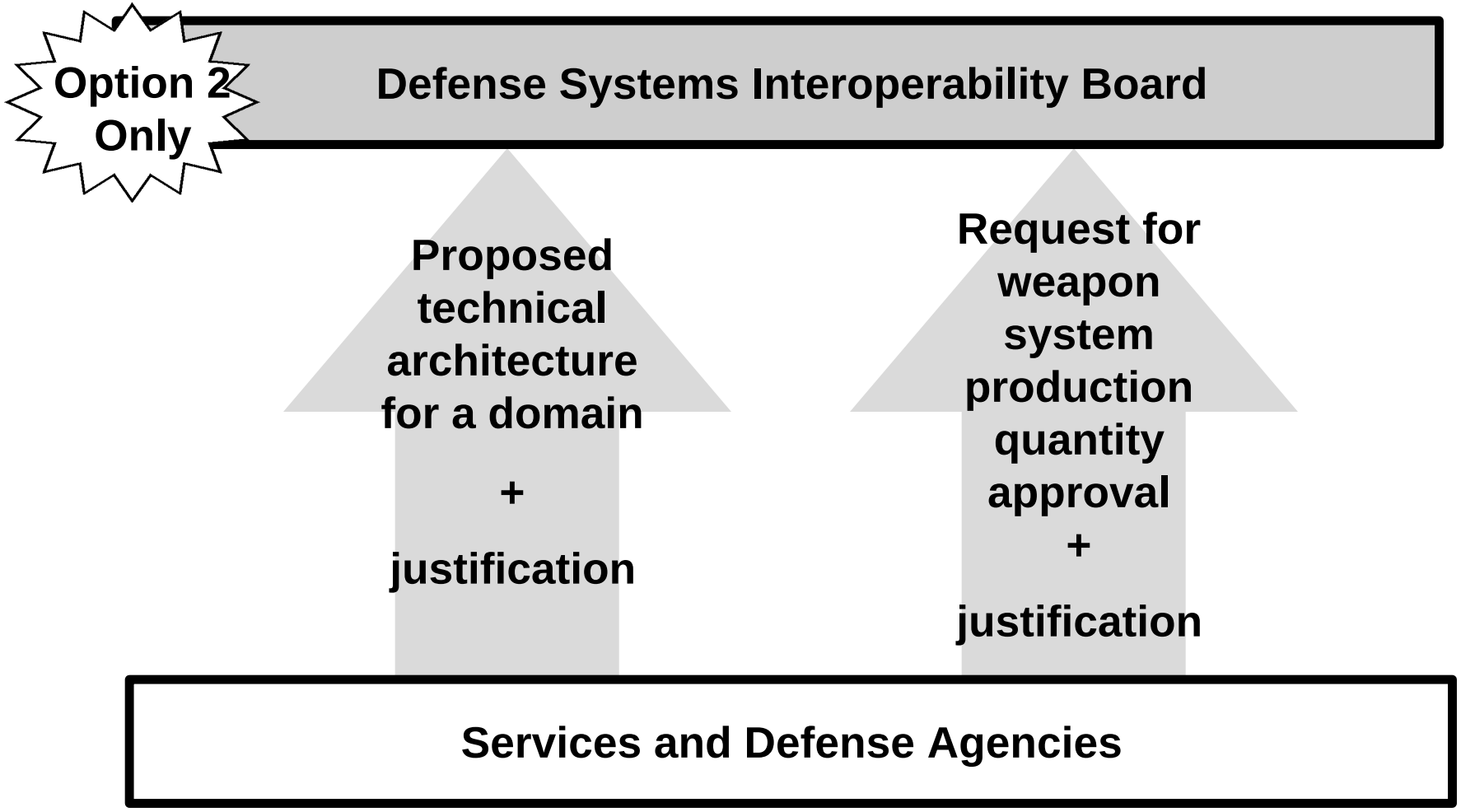
Services and Agencies Seek Approval for Architectures and Production

NDRI



A Federally Funded Research and Development Center Assists the DSIB

NDRI

Option 2 Only

Defense Systems Interoperability Board

Monitoring of interoperability performance

- Time to insert new technology
- Weapon system electronics costs
- Joint forces performance

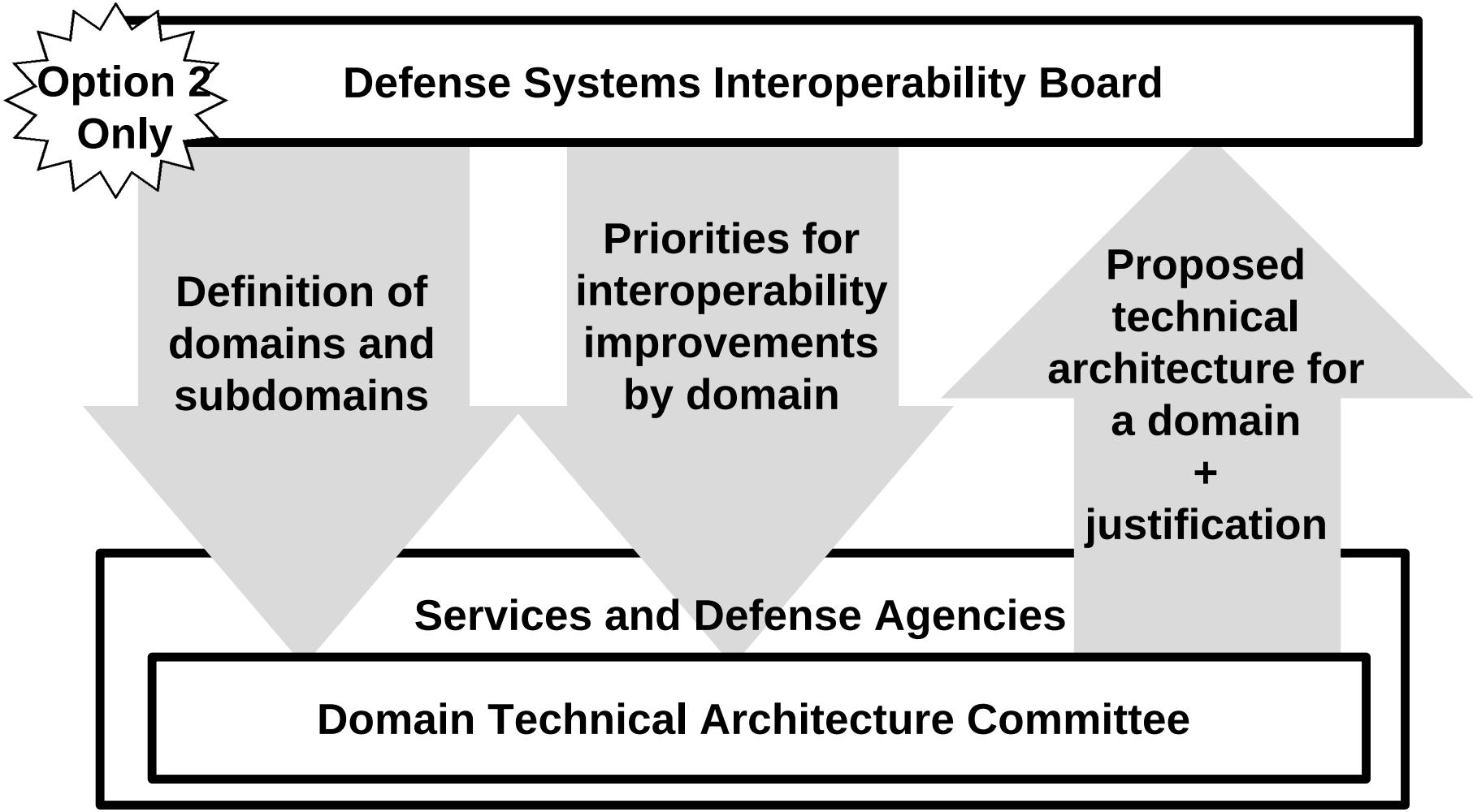
Technical review of domain technical architectures

Analysis of weapon system interoperability suitability for each acquisition milestone review

Defense Systems Interoperability FFRDC

The Domain Technical Architecture Committee Is within Services/Agencies

NDRI



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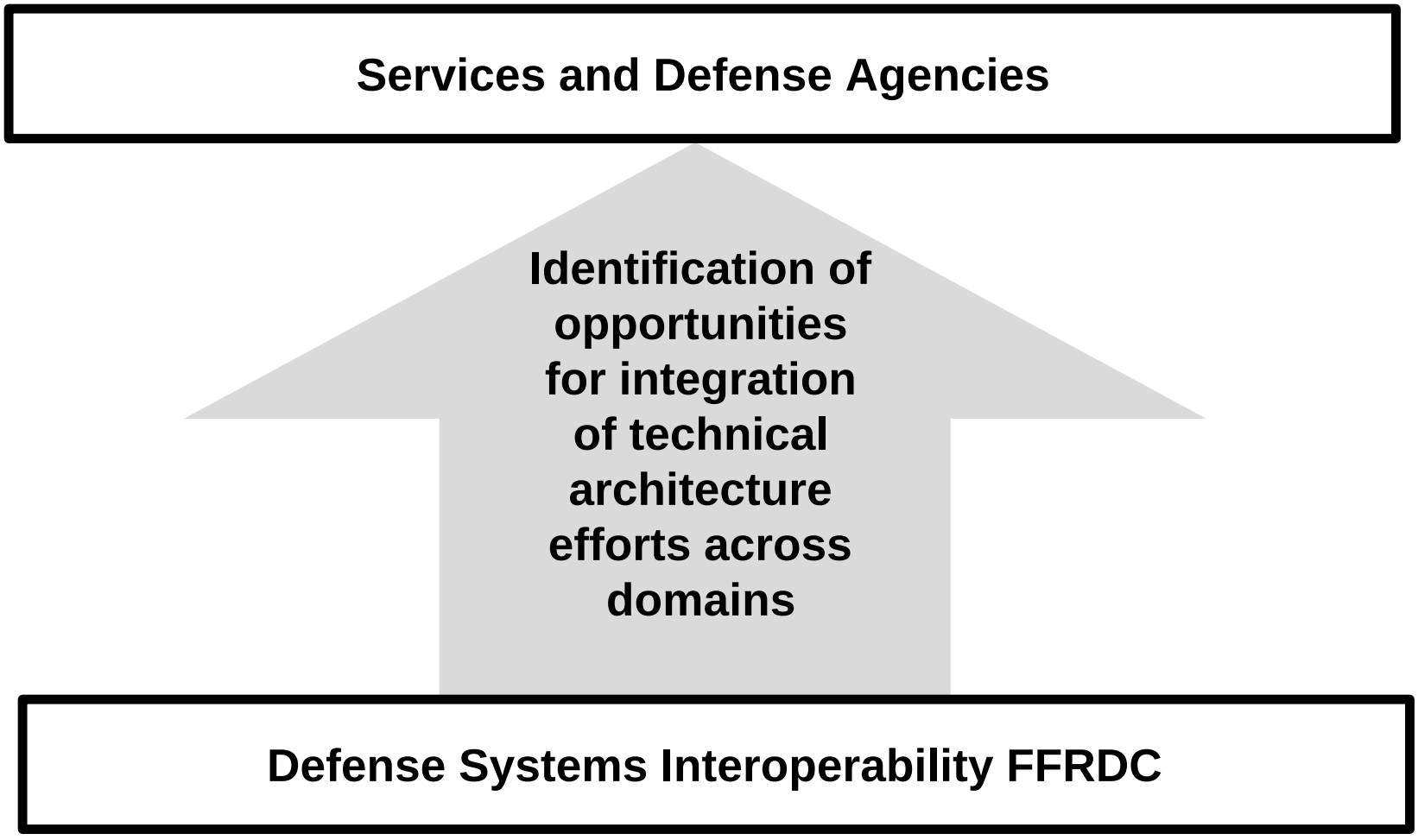
An Interoperability FFRDC Could Facilitate Integration Across Domains

NDRI



Outline

NDRI

I. Introduction

II. Methodology

III. Pilot test

IV. Conclusions

V. Next steps

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Phases of the Pilot Test

NDRI

Phase I: Prepare a plan for the test

Phase II: Execute the plan

Phase III: Analyze the pilot test results

Phase IV: Refine the method for developing technical architectures

Phase I: Prepare a Plan for the Test

NDRI

A. Develop support for concept of a pilot test

- OSD, A&T and C3I
- Service and defense agency acquisition executives

B. Develop a specific concept for the pilot test

- Test objectives and extent of the test
- Domain for the pilot test: participating weapon system programs

C. Develop the test plan with the participants

- Roles, activities, and milestones
- Memoranda of agreement for participants

D. Arrange for test support

- Inputs from other organizations (CINCs, Joint Staff)
- Funding, and contractor support

Phase II: Execute the Test Plan

NDRI

Proposed participants for the pilot test

- Organizations involved in the development of the technical architecture
- Organizations invovled in providing guidance for the development of the technical architecture
- Organizations involved in facilitating the test and evaluating the outcome

Proposed Participants for the Pilot Test

NDRI

- **Development of the technical architecture**
  - **Domain Technical Architecture Committee**
  - **Participating acquisition programs**
  - **Service acquisition organizations**
  - **Domain Technical Support Contractors**
- **Guidance (Option 2, only)**
  - **Defense Systems Interoperability Board**
  - **Combatant CINCs and Joint Staff**
  - **Defense Systems Interoperability Council**
- **Facilitation and evaluation**
  - **Undersecretary for Acquisition and Technology**
  - **Participating services and defense agencies**
  - **Joint Test Team and Interoperability FFRDCs**

Domain Technical Architecture Committee (Role During Pilot Test, 1 of 3)

NDRI

- **Review and provide comments on**
  - **Draft report: *Strategy for Improving Interoperability of Weapon System Electronics***
  - **Draft test plan**
- **Assimilate guidance from the Defense Systems Interoperability Board (Option 2 only)**
  - **Domain's interoperability improvement priorities**
- **Use improvement priorities to**
  - **Select tactics needing improvement**
    - » **Reduce Mil Specs**
    - » **Increase reuse**
    - » **Improve interoperation**
  - **Focus technical architecture development effort**

Domain Technical Architecture Committee (Role During Pilot Test, 2 of 3)

NDRI

- Tailor the technical architecture development methodology to suit the domain's priorities
- Develop the technical and business concepts for improving interoperability
  - Design alternative approaches
  - Conduct tradeoff studies
    - » Consider As-Is case and alternatives
    - » Consider affects on the life-cycle costs for the weapon systems in the domain
    - » Examine influence on DoD's total cost
  - Select a preferred concept
  - Obtain approval of the participating services and agencies for the preferred concept

Domain Technical Architecture Committee (Role During Pilot Test, 3 of 3)

NDRI

- **Develop the technical and business approach**
  - **Work with domain members and the Domain Technical Support Contractor**
  - **Secure approval of the participating services and agencies for the improvement approach**
- **Complete the technical architecture document**
  - **Obtain independent reviews (technical and business)**
  - **Submit to the Defense Systems Interoperability Board for approval (Option 2 only)**
- **Evaluate test results and recommend changes**

Participating Acquisition Programs (Role During Pilot Test)

NDRI

- **Review and provide comments on**
  - **Draft report: *Strategy for Improving Interoperability of Weapon System Electronics***
  - **Draft test plan**
- **Assist A&T in defining test scope**
  - **Test objectives and extent of the test**
  - **Domain for the pilot test: participating weapon system programs**
- **Assign acquisition staff to**
  - **Domain Technical Architecture Committee**
- **Improve weapon system development program**
  - **Domain technical architecture provides improvement**
- **Evaluate test results and recommend changes**

Service Acquisition Organizations (Role During Pilot Test, 1 of 2)

NDRI

- Review and provide comments on
  - Draft report: *Strategy for Improving Interoperability of Weapon System Electronics*
  - Draft test plan
- Assist A&T in defining test scope
  - Test objectives and extent of the test
  - Domain for the pilot test, type(s) of equipment, and participating programs
- Assign staff to
  - Domain Technical Architecture Committee
  - Joint test team
- Select a chair for the Domain Technical Architecture Committee

Service Acquisition Organizations (Role During Pilot Test, 2 of 2)

NDRI

- Review progress of the Domain Technical Architecture Committee
- Review and approve the technical architecture that is developed
- Commit the service/agency to supporting and applying the technical architecture
- Use the domain technical architecture in reviewing the domain's acquisition programs
- Evaluate test results and recommend changes

Domain Technical Support Contractors (Role During Pilot Test)

NDRI

- **Review and provide comments on**
  - **Draft report: *Strategy for Improving Interoperability of Weapon System Electronics***
  - **Draft test plan**
- **Assign staff to**
  - **Domain Technical Architecture Committee**
  - **Joint Test Team**
- **Facilitate the work of the Domain Technical Architecture Committee**
  - **Perform analyses and tradeoff studies**
  - **Facilitate meetings**
  - **Draft materiel for the technical architecture**
  - **Prepare the technical architecture document**

Proposed Participants for the Pilot Test

NDRI

- **Development of the technical architecture**
  - **Domain Technical Architecture Committee**
  - **Particpating acquisition programs**
  - **Service acquisition organizations**
  - **Domain Technical Support Contractors**
- **Guidance (Option 2, only)**
  - **Defense Systems Interoperability Board**
  - **Combatant CINCs and Joint Staff**
  - **Defense Systems Interoperability Council**
- **Facilitation and evaluation**
  - **Undersecretary for Acquisition and Technology**
  - **Participating services and defense agencies**
  - **Joint Test Team and Interoperability FFRDCs**

Option 2 Only

Defense Systems Interoperability Board (Role During Pilot Test)

NDRI

- For weapon systems in the test domains
  - Provide assessments of interoperability performance to Combatant CINCs and Joint Staff
  - Analyze CINC and Joint Staff feedback about prioritized needs for improved interoperability
- Provide improvement priorities to Domain Technical Architecture Committees
- For each test domain, review the domain's
  - Test progress and technical architecture
  - Acquisition programs
- Provide inputs to acquisition milestone reviews
  - Assessment of interoperability suitability
- Evaluate test results and recommend changes

Option 2 Only

Combatant CINCs and Joint Staff (Roles During Pilot Test)

NDRI

- **Review and provide comments on**
  - **Draft report: *Strategy for Improving Interoperability of Weapon System Electronics***
  - **Draft test plan**
- **For weapon systems in the test domains:**
  - **Review assessment of interoperability performance provided by the acting DSIB**
  - **Prioritize needs for improved interoperability**
  - **Share priorities with the acting DSIB**
- **Evaluate test results and recommend improvements to the methodology**

Option 2 Only

Defense Systems Interoperability Council (Role During Pilot Test)

NDRI

- **Review and provide comments on**
  - **Draft report: *Strategy for Improving Interoperability of Weapon System Electronics***
  - **Draft test plan**
- **For weapon systems in the test domain**
  - **Analyze**
    - » **DSIB's assessment of interoperability performance**
    - » **CINC and Joint Staff prioritized needs for improved interoperability**
    - » **Actions that industry could assist or take**
  - **Make recommendations to the DSIB**
- **Evaluate test results and recommend changes**

Proposed Participants for the Pilot Test

NDRI

- **Development of the technical architecture**
  - **Domain Technical Architecture Committee**
  - **Particpating acquisition programs**
  - **Service acquisition organizations**
  - **Domain Technical Support Contractors**
- **Guidance (Option 2, only)**
  - **Defense Systems Interoperability Board**
  - **Combatant CINCs and Joint Staff**
  - **Defense Systems Interoperability Council**
- **Facilitation and evaluation**
  - **Undersecretary for Acquisition and Technology**
  - **Participating services and defense agencies**
  - **Joint Test Team and Interoperability FFRDCs**

Undersecretary for Acquisition and Technology (Roles During Pilot Test)

NDRI

- Approve test concept; assign test director & staff
- Designate boards/groups to serve as acting
  - Defense Systems Interoperability Board (Option 2 only)
  - Defense Systems Interoperability Council (Option 2 only)
- Secure support of participating organizations
  - CINCs, Joint Staff (Option 2 only)
  - Service acquisition executives
  - Acquisition programs, and service acquisition orgs
- Review and approve test plan
- Arrange for test support
- Review test progress
- Evaluate test results & expand to more domains

Participating Services and Defense Agencies (Role During Pilot Test)

NDRI

- Review and provide comments on
  - Draft report: *Strategy for Improving Interoperability of Weapon System Electronics*
  - Draft test plan
- Assist A&T in defining test scope
  - Test objectives and extent of the test
  - Domain for the pilot test: participating weapon system programs
- Assign acquisition staff to the joint test team
- For each test domain, review the domain's
  - Test progress, technical architecture and acq. pgms
- Evaluate test results and recommend changes

Joint Test Team (Role During Pilot Test)

NDRI

- **Review and provide comments on**
  - **Draft report: *Strategy for Improving Interoperability of Weapon System Electronics***
- **Assist the DTAC in preparing the test plan**
- **Facilitate execution of the test plan**
- **Monitor progress of the test**
  - **Observe performance of the Domain Technical Architecture Committee**
- **Evaluate test results and recommend changes**

Interoperability FFRDCs (Role During Pilot Test)

NDRI

- **Review and provide comments on**
  - **Draft report: *Strategy for Improving Interoperability of Weapon System Electronics***
  - **Draft test plan**
- **Assign staff to observe and assist**
  - **Domain Technical Architecture Committee**
  - **Joint Test Team**
- **Facilitate the work of the Defense Systems Interoperability Board**
  - **Assess interoperability performance**
  - **Evaluate domain technical architectures**
- **Evaluate test results and recommend changes**

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NDRI

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Conclusions

NDRI

- **Improving interoperability**
  - **Requires up front investment**
  - **Yields downstream dividends for warfighters**
- **Goal-oriented focus, such as improving interoperability, would provide**
  - **Basis for communicating needs, conducting tradeoff studies, and focusing resources**
- **Extension of the technical architecture approach to weapon systems**
  - **Promising concept, a method is available**
  - **Requires effort and cooperation**
- **Pilot test needed**

Outline

NDRI

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Next Steps

NDRI

- OS-JTF decisions
  - Suitability of methodology
  - Readiness of methodology for a pilot test
  - Domain for a pilot test
- USD A&T decision to support a pilot test
- Preparation for a pilot test
  - Funding and contractor support for a pilot test

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Subsequent Steps of the Strategy

NDRI

Step 1: design a methodology for developing a technical architecture for a domain of weapon system electronics

Step 2: pilot test the methodology

Step 3: extend the application of the methodology to additional demonstrations

Step 4: implement the methodology and integrate the technical architectures across services and domains